TEMPLETON'S

MILLWRIGHT & ENGINEER'S POCKET COMPANION.

EIGHTH EDITION,

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With Four Lithographic Illustrations.

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WORKS
BY WILLIAM TEMPLETON.

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THE

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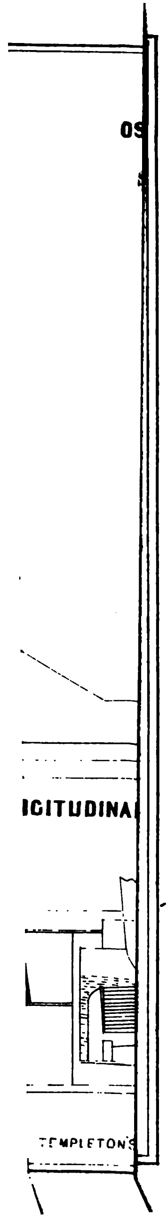
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THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION:

COMPRISING

DECIMAL ARITHMETIC,
TABLES OF SQUARE AND CUBE ROOTS,
PRACTICAL GEOMETRY,
MENSURATION,
STRENGTH OF MATERIALS,
MECHANIC POWERS,
WATER WHEELS,
PUMPS AND PUMPING ENGINES,
STEAM ENGINES,
TABLES OF SPECIFIC GRAVITY,
&c., &c., &c.

ALSO, A SERIES OF

MATHEMATICAL TABLES;

CONTAINING THE CIRCUMFERENCES, SQUARES, CUBES, AND AREAS OF CIRCLES, SUPERFICIES, AND SOLIDITY OF SPHERES,
&c., &c., &c.

EIGHTH EDITION.

REVISED, CORRECTED, AND ENLARGED.

BY WILLIAM TEMPLETON,

Author of "The Engineer's Common Place Book of Practical Reference," and "Locomotive Engine Popularly Explained."

WITH LITHOGRAPHIC ILLUSTRATIONS.

LONDON:

PUBLISHED BY SIMPKIN, MARSHALL, AND CO., STATIONERS'-HALL-COURT; SOLD ALSO BY G. HEBERT, 88, CHEAPSIDE, LONDON; SMITH, ROGERSON, AND CO., LIVERPOOL; J. AND J. THOMPSON, MANCHESTER; JAMES BELL, NEW-STREET, BIRMINGHAM; BLACK AND CO., EDINBURGH; AND BY ALL BOOKSELLERS.

1848.

ENTERED AT STATIONERS' HALL.

LIVERPOOL: PRINTED BY SMITH, ROGERSON, AND CO., LORD-STREET.

ADVERTISEMENT.

If the rapid and continuous sale of a work be any test of its value, "Templeton's Engineer and Millwright's Pocket Companion" is a volume of no little merit, since it has already passed through seven tolerably large editions, and circulated chiefly amongst that class of the British population engaged in engineering and other mechanical pursuits. In issuing the EIGHTH EDITION of the work, the Proprietors are glad to state that they present it to the public with higher claims to their notice than those of any preceding edition, and, more especially, since it has undergone a revision by an intelligent Practical Engineer, and also by a Teacher of Mathematics. In the departments of Arithmetic, Practical Geometry, and Mensuration, it has been somewhat enlarged. In Practical Geometry, for instance, nearly a score of new problems have been added, which will, no doubt, be found very useful to the Practical Engineer and Mechanic; also, a series of Mathematical Tables, originally published in a separate form, and more complete than any that has yet appeared in former editions, is here given, rendering the work of such importance to the practical man, that no person for whose benefit it was principally intended ought to be without a copy. It may here also be stated, that in addition to the Lithographic Drawings which appeared in former editions, another is given, namely, that of an Oscillating Marine Engine. The above improvements and additions have occasioned

considerable expense, but the Proprietors have much pleasure in announcing that the work, nevertheless, has been materially reduced in price, so that it may be more readily accessible to the majority of the working classes than it has hitherto been.

Of the work itself it may be observed, that it was originally undertaken with a view to facilitate the calculations of Millwrights, Engineers, Ironfounders, &c., and by them it is to be hoped it will be duly appreciated, more especially when they consider that the subjects treated of (with very few exceptions) have been diffused throughout a number of valuable and extensive works, quite out of the reach of mechanics in general, and too voluminous to be made useful where they were most required. Indeed, the greater part of mechanical works have been swelled out by theoretical problems, too tedious for practical men,—a defect which is here obviated, by commencing with a system of decimals, and carrying on the work throughout entirely on that system.

Various original and useful rules, well adapted for mechanical calculations, will be found interspersed throughout the pages of the work; and with regard to the subjects selected, no comment is necessary, as every mechanic is well aware that one or other of them is required daily.

With the above recommendations of the work, the Proprietors now offer it to the public, feeling assured of a continuance of that patronage which it has always been their study to merit by their best efforts to render the "Engineer and Millwright's Companion" a truly practical and useful book.

Liverpool, July, 1848.

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Miscellanies.

Mathematical Tables.

THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION.

EXPLANATION

OF THE SIGNS OR CHARACTERS NOW GENERALLY MADE USE OF IN ALL SORTS OF CALCULATIONS.

$=$ signifies Equality, as.....4 added to 3 is equal to 7.

$+$ signifies Addition, as..... $5 + 3 = 8$.

$-$ signifies Subtraction, as ..... $5 - 3 = 2$.

$\times$ signifies Multiplication, as ..... $5 \times 3 = 15$.

$\div$ signifies Division, as..... .....$15 \div 3 = 5$, or $\frac{15}{3}$.

$:::$ signifies Proportion ..... as 2 is to 3, so is 4 to 6.

$\surd$ signifies Square Root, as .... $\surd 9 = 3$.

$\sqrt[3]{}$ signifies Cube Root, as .....$\sqrt[3]{27} = 3$.

3^2 signifies that 3 is to be squared, as..... $3^2 = 9$.

3^3 signifies that 3 is to be cubed, as ..... $3^3 = 27$.

$\overline{3 + 5} \times 3 = 24$ the Bar signifies that two, three, or more numbers are to be taken together, as 3 added to 5 = 8, and 3 times 8 = 24.

$\surd \overline{5^2 - 3^2} = 4$ signifies that 3 squared taken from 5 squared, and the square root extracted = 4.

$\sqrt[3]{\frac{20 \times 12}{30}} = 2$ signifies that when 20 is multiplied by 12, and divided by 30, the cube root of the quotient = 2.

OF WEIGHTS AND MEASURES.

Avoirdupois Weight is the only weight made use of in mechanical calculations; and all metals, save gold and silver, are weighed by it: hence, it is not requisite here to take any other into consideration.

				Fr. Grammes.
	= 1 Dram	=		1.771
16 Drams	= 1 Ounce	=		28.346
16 Ounces	= 1 Pound	=		453.544
28 Pounds	= 1 Quarter	=		12.699 kilog.
4 Quarters	= 1 Hundred wt	=		50.796 „
20 Hundred wt	= 1 Ton	=		1015.920 „

NOTE.—5760 Troy grains = 1 pound Troy; and 7000 Troy grains = 1 pound Avoirdupois; hence, 175 pounds Troy = 144 pounds Avoirdupois.

Or, Avoirdupois	lbs. ×	1.21527	= Troy lbs.
Do.	ounces ×	.9115	= Do. ounces.
Troy	lbs. ×	.823	= Avoir. lbs.
Do.	ounces ×	1.1	= Do. ounces.
Do.	grains ×	.03657	= Do. drams.
Also, Avoirdupois	lbs. ×	.00893	= Cwts.
And, Do.	lbs. ×	.000447	= Tons nearly.

TABLES,

Showing the relative Proportion between Foreign Weights and the Avoirdupois Pound.

1. FRENCH WEIGHTS.—DECIMAL SYSTEM.

1 Milligramme	=	.0154 Troy grains.
1 Centigramme	=	.1543 „
1 Decigramme	=	1.5434 „
1 Gramme	=	15.4340 „
1 Decagramme	=	154.3402 „
1 Hectogramme	=	1543.4023 „
1 Killogramme	=	2.20486 lbs. Avoirdupois.
1 Myriagramme	=	22.0486 „
1 Quintal	=	1 cwt. 3 qrs. 25 lbs. nearly.
1 Millier or Bar	=	9 tons. 16 cwt. 3 qrs. 12 lbs.

2. SYSTEME USUEL.

The Kilogramme	=	1000	Grammes	=	2 lbs.	3 oz.	4½	Dr. Av.
The Livre Usuel	=	500	„	=	1 „	1 „	10½	„
The Half	=	250	„	=		8 „	13¾	„
The Quarter.....	=	125	„	=		4 „	6⅞	„
The Eighth	=	65.5	„	=		2 „	3½	„
The Once	=	31.3	„	=		1 „	1¾	„
The Half	=	15.6	„	=			8¾	„
The Quarter.....	=	7.8	„	=			4⅜	„
The Gros	=	3.9	„	=			2¼	„

3. VARIOUS FOREIGN WEIGHTS IN POUNDS AVOIRDUPOIS.

Places & names of weights.	*Lbs.*	*Places & names of weights.*	*Lbs.*
Alexandria { rotola forfora....	.9347	Genoa.....peso sottile	.6988
„ rotola zaidino	1.335	„ peso grosso	.7687
„ rotola zauro..	2.07	Hamburgh .....pound	1.068
„ rotola mina..	1.67	Havannah .....pound	1.075
Amsterdam .. old pound	1.09	Leghorn .....pound	.764
„ new ditto	2.206	Madras.....vis	3.125
Antwerp.....old pound	1.033	Malabar .. ..visay	3.001
„ new ditto	2.206	Malta .....rotola	1.745
Bahia, Lisbon, and Oporto } Aragal	1.012	Mocha.....rotola	1.125
Barcelona .....pound	.882	Mogadore { commercial pound	1.19
Batavia .....catty	1.36	„ market pound	1.781
Bergen ..... Christina, and Copenhagen.. } pound	1.1025	Naples.....rotola	1.965
Bombay .....seer	.7	Odessa and Petersburgh } pound	.9019
Bremen .....pound	1.098	Port-au-Prince and Port Louis } livre poids de marc.	1.06
Buenos Ayres, Cadiz, Lima, Malaga, Valparaiso, and Vera Cruz.. } pound	1.015	Riga .....pound	.9217
		Rio de Janeiro....aragal	1.01
		Rotterdam .....pound	2.204
		Smyrna .....oke	2.82
Calcutta.....seer	2.058	Stockholm { commercial pound	.9375
Canton & Manilla..catty	1.333	„ iron weight	.75
Cape Town .....pound	1.09	Trieste .....pound	1.236
Constantinople .....oke	2.828	Venice .....peso grosso	1.0518
Dantsic & Memel..pound	1.033	„ peso sottile	.6643

NOTE.—America, the British West Indies, Gibraltar, and Van Dieman's Land use the pound Avoirdupois, as in England.

EXAMPLE 1.—Suppose I purchase an article in London which weighs 50 lbs. Avoirdupois, what will it weigh in Amsterdam according to their new weight?

$50 \div 2.207 = 22.606$ or 22 lbs. 9 oz. 11.137 dr. Avoirdupois.

EX. 2.—An article that weighs 60 lbs. in Leghorn, according to their weight, what will it weigh in lbs. Avoirdupois?

$.764 \times 60 = 45.84$ lbs. Avoirdupois nearly.

LONG MEASURE.

				Fr. Metres.
12 Inches	= 1	Foot	=	.3048
3 Feet	= 1	Yard	=	.9144
6 Feet	= 1	Fathom	=	1.8288
5½ Yards	= 1	Pole or rod	=	5.0291
40 Poles	= 1	Furlong	=	201.1632
8 Furlongs or 1760 yards	= 1	Mile	=	1609.3059
Miles	= 1	League	=	4827.9179

Surveying Chain = 22 yards, consists of 100 links, and each link = 7.92 inches.

FRENCH LONG MEASURE.—DECIMAL SYSTEM.

French.		English.
1 Millimetre	=	.03937 inches.
1 Centimetre	=	.39371 „
1 Decimetre	=	3.93710 „
1 Metre	=	39.37100 „
1 Decametre	=	32.80916 feet.
1 Hectometre	=	328.09167 „
1 Kilometre	=	1093.63890 yards.
1 Myriametre	=	10936.38900 „

SYSTEME USUEL.

Usuel.		Metrical.		English.
1 Ligne	= 2.31	Millimetres	=	.091 inches.
1 Pouce	= 2.77	Centimetres	=	1.090 „
1 Pied	= 3.33	Decimetres	=	13.110 „
1 Aune	=12.	Decimetres	=	3 feet 11.24 inches.
1 Toise	= 2.	Metres	=	6 feet 6.74 inches.

THE LINEAL FOOT OF VARIOUS COUNTRIES, GIVEN IN ENGLISH INCHES.

	Inches.		Inches.
Amsterdam & Antwerp	=11.143	Canton	= 12.65
Bahia, Lisbon, and Rio de Janeiro	=12.944	Dantzic and Memel	= 11.3
Bergen, Copenhagen, Cape Town, Christiana, and Hamburgh	=12.36	Port-au-Prince and Port Louis	= 12.8
		Riga	= 10.79
		Stockholm	= 11.684
		Venice	= 13.68

NOTE.—The English foot is used generally throughout America, the British West Indies, Russia, and Van Dieman's Land.

LENGTH OF A MILE IN DIFFERENT COUNTRIES, GIVEN IN ENGLISH YARDS.

	Yards.		Yards.
Dantzic	8474	Poland	8239
Denmark	8244	Portugal	6760
Flanders	6864	Prussia	8237
Germany	6859	Russia	1167
Hanover	1155	Scotland	1984
Holland	8239	Spain	4634
Hungary	9113	Sweden	1170
Ireland	2240	Switzerland	9153
Netherlands	1093	Tuscany	1808

SUPERFICIAL MEASURE.

				Fr. Sq. Metres.
144	Square inches	= 1	Sq. foot	= .0929
9	Square feet	= 1	Sq. yard	= .8361
30¼	Square yards	= 1	Sq. pole	= 25.2916
40	Square poles	= 1	Rood	= 1011.6662
4	Roods, or 4840 Sq. yards	= 1	Acre	= 4046.6648

A Scotch Acre contains 6084 square yards,
And an Irish Acre contains 7840 square yards.

FRENCH SUPERFICIAL MEASURES.

1	Centiare	=	1.1960 Square yards.
1	Arc (a square decametre)	=	119.6046 „
1	Decare	=	1196.0460 „
1	Hectare	=	11960.4604 „

or 2 acres 1 rood 35 perches.

SOLID MEASURE.

				Fr. Cubic Metres.
1728	Cubic inches	= 1	Cubic foot	= .0283
27	Cubic feet	= 1	Cubic yard	= .7645
42	Cubic feet	= 1	Ton of Shipping	= 1.1892

A Load of unhewn timber = 40 Cubic feet.
„ squared do = 50 „
„ 1 inch plank = 600 Square feet.
„ 1½ inch do. = 400 „
„ 2 inch do. = 300 „

NUMBER OF CUBIC FEET IN A TON OF VARIOUS BODIES.

Names of Bodies.	Cubic feet in a ton.	Names of Bodies.	Cubic feet in a ton.
Marble	13.07	Beech	50.5
Granite	13.5	Teak	48
Common Stone	14.22	Span. Mahogany.	42
Paving do	14.83	Honduras do	64
Sand	23.5	Maple & Riga Fir	47.8
Coal	28.7	Larch	65.8
Tallow	38	Pitch Pine	53.6
English Oak	37	Oil	39
American do.	41	Proof Spirits	38.6
Ash	47	Distilled Water.	35.8
Elm	64.5	Sea do	34.7

A Gallon of	Oil weighs	9.32 lbs.	Avoirdupois.
„	Distilled Water	10	„
„	Sea Water	10.32	„
„	Proof Spirits	9.3	„

IMPERIAL WINE MEASURE.

	1 Gill	=	8.665	cubic inches.
4 Gills	= 1 Pint	=	34.659	„
2 Pints	= 1 Quart	=	69.318	„
4 Quarts	= 1 Gallon	=	277.274	„
10 Gallons	= 1 Anker	=	1.604	cubic feet.
18 Gallons	= 1 Runlet	=	2 888	„
42 Gallons	= 1 Tierce	=	6.739	„
63 Gallons	= 1 Hogshead	=	10.109	„
84 Gallons	= 1 Puncheon	=	3.478	„
126 Gallons	= 1 Pipe	=	20.218	„
252 Gallons	= 1 Tun	=	40.435	„

FRENCH MEASURES OF CAPACITY.

1 Millitre	=	.06103	cubic inches.
1 Centilitre	=	.61028	„
1 Decilitre	=	6.10280	„
1 Litre (a cubic decimitre)	=	61 02803	„
1 Decalitre	=	610.28028	„
1 Hectolitre	=	3.5317	cubic feet.
1 Kilolitre	=	35.3171	„
1 Myrialitre	=	353.17146	„
The Litron usuel	=	62.45	cubic inches.

A TABLE

Showing the relative value between the British Imperial Gallon and Foreign measures of capacity.

Places and names of measures.	Imp. Gall.	Places and names of measures.	Imp. Galls.
Amsterdam..mingle	.266	Havannah ...arroba	3.416
„ .....kan	.220	Leghorn wine fiasco	.499
Antwerp ...stoopen	.608	„ ...oil fiasco	.443
„ ..... litre	.220	Lisbon .....almude	3.641
Barcelona ...cortane	2.270	Malta .....catfiso	4.582
Bordeaux .....velte	1.672	Mocha .....cuda	1.666
Cadiz...great arroba	3.540	Naples wine barilla	9.164
„ ...small arroba	3.124	„ ...oil staja...	2.226
Constantinople.alma	1.146	Oporto ..... almude	5.311
Dantzic..beer anker	12.925	Petersburgh wedro	2.707
„ wine anker	9.915	Rotterdam ...stoop	.564
Genoa...wine barilla	16.349	Stockholm ...kanne	.575
„ .....oil barilla	14.162	Trieste .....boccali	.312
Gibraltar.....gallon	.909	Venice...wine sechii	2.377
Hamburgh stubjen	.797	„ .....oil miro	3.356

NOTE.—America, the British West Indies, and Van Dieman's Land, use the same measures of capacity as in England.

IMPERIAL ALE AND BEER MEASURE.

	1	Gill.....	=	8.665	cubic inches.
4 Gills	= 1	Pint	=	34.659	„
2 Pints	= 1	Quart.....	=	69.318	„
4 Quarts	= 1	Gallon	=	277.274	„
9 Gallons	= 1	Firkin	=	1.444	cubic feet.
18 Gallons	= 1	Kilderkin ...	=	2.888	„
36 Gallons	= 1	Barrel	=	5.776	„
54 Gallons	= 1	Hogshead ...	=	8.664	„
72 Gallons	= 1	Puncheon ...	=	11.553	„
108 Gallons	= 1	Butt	=	17.329	„

NOTE.—The old Ale Gallon contained 282 cubic inches, and the old Wine Gallon contained 231, hence—

Imperial Gallons.....	× .98324	=	old Ale Gallons.
Imperial Gallons.....	× 1.20032	=	old Wine Gallons.
Old Ale Gallons	× 1.01704	=	Imperial Gallons.
Old Wine Gallons	× .83311	=	Imperial Gallons.
Cubic feet	× 6.232	=	Imperial Gallons.
Cubic inches.....	× .003607	=	Imperial Gallons.

IMPERIAL DRY MEASURE.

		1 Gill	=	8.665	cubic inches.
4 Gills	=	1 Pint	=	34.659	„
2 Pints	=	1 Quart	=	69.318	„
4 Quarts	=	1 Gallon	=	277.274	„
2 Gallons	=	1 Peck	=	554.548	„
4 Pecks	=	1 Bushel	=	1.2837	cubic feet.
8 Bushels	=	1 Quarter	=	10.2694	„
32 Bushels	=	1 Chaldron	=	41.0784	„
40 Bushels	=	1 Way	=	51.3480	„
80 Bushels	=	1 Last	=	102.6960	„

NOTE.—The Winchester bushel contained 2150.42 cubic inches, and the Imperial bushel contains 2218.192 cubic inches, hence,—
Imperial bushels ..... × 1.0315157 = Winchester bushels,
and Winchester bushels... × .969447 = Imperial bushels.

A bushel of wheat is reckoned	=	60	lbs. Avoirdupois,
„ barley	=	47	„
„ oats	=	38	„
„ pease	=	64	„
„ beans	=	63	„

IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FISH, POTATOES, FRUIT, AND OTHER GOODS.

The Gallon	=	351.9375	cubic inches.	
2 Gallons	=	1 Peck	=	703 875 cubic inches.
4 Pecks	=	1 Bushel	=	2815.5
3 Bushels	=	1 Sack	=	4.888 cubic feet nearly.
12 Sacks	=	1 Chaldron	=	58.656

DIMENSIONS OF DRAWING PAPER IN FEET AND INCHES.

Wove Antiquarian	4	feet	4	inches	by 2	feet	7	inches.
Double Elephant	3	„	4	„	by 2	„	2	„
Atlas	2	„	9	„	by 2	„	2	„
Columbier	2	„	9¾	„	by 1	„	11	„
Elephant	2	„	3¾	„	by 1	„	10¼	„
Imperial	2	„	5	„	by 1	„	9¼	„
Super royal	2	„	3	„	by 1	„	7	„
Royal	2	„	0	„	by 1	„	7	„
Medium	1	„	10	„	by 1	„	6	„
Demy	1	„	7½	„	by 1	„	3½	„

DIMENSIONS OF IMPERIAL CONICAL LIQUID MEASURES.

Diameters.

Two Gallon...	Top	$2\frac{1}{2}$	in...	Bottom $11\frac{1}{2}$	in...	Depth 12.66498 in.
Gallon	„	2	„	9	„	10.28498
Half Gallon...	„	$1\frac{3}{4}$	„	7	„	8.23415
Quart	„	$1\frac{1}{4}$	„	$5\frac{3}{4}$	„	6.33249
Pint	„	1	„	$4\frac{1}{2}$	„	5.14249
Half Pint.....	„	$\frac{7}{8}$	„	$3\frac{1}{2}$	„	4.11708
Gill	„	$\frac{3}{4}$	„	$2\frac{7}{8}$	„	3.16625

DIMENSIONS OF IMPERIAL CYLINDRICAL DRY MEASURES.

Diameters and Depths.

Eighth of a Peck.....a cylinder of		4.45232 inches.
Forpit or Half Gallon..	„	5.60957
Gallon or Half Peck ...	„	7.06762
Peck	„	8.90464
Half Bushel.....	„	11.21914
Bushel	„	14.13524
Quarter	„	28.27048

NOTE.—Multiply the decimal by 8, the product equal inches and parts of an inch.

DECIMAL FRACTIONS.

A Decimal Fraction derives its name from the Latin, *decem*, "ten," which denotes the nature of its numbers, representing the parts of an integral quantity, divided into a tenfold proportion.

NUMERATION

Teacheth to read or write any number proposed, either by words or characters.

In Decimal Fractions, the integer, or whole thing, as a gallon, a pound, a yard, &c., is supposed to be divided into ten equal parts, called tenths; those tenths into ten equal parts, called hundredths; and those hun-

dredths into ten equal parts, called thousandths; and so on, without end. So that the denominator of a decimal being always known to consist of a unit, with as many ciphers as the numerator has places, is, therefore, never expressed, being understood to be 10, 100, 1000, 10,000, &c., according as the numerator consists of 1, 2, 3, 4, or more figures; thus, instead of $\frac{2}{10}$, $\frac{24}{100}$, $\frac{211}{1000}$, the numerators only are written with a dot or comma before them, thus, .2, .24, .211.

If a unit or whole quantity of any description, as a gallon, a pound, a foot, &c., be divided into ten equal parts, the decimal represents as many of those parts as the decimal figure expresses,—thus, .7 means seven of those parts, or seven-tenths; but if the decimal consisted of two figures, unity would be understood to be divided into a hundred equal parts, of which the decimal represents as many as the figure expresses,—thus .65 means sixty-five of those parts, or sixty-five hundredths; and if the decimal consisted of three figures, unity would be supposed to be divided into a thousand equal parts, of which the decimal represents as many as the number expresses,—thus .625 is six hundred and twenty-five of those parts; or, suppose the decimal .0625, unity would be understood to be divided into 10,000 equal parts; but the value of decimal figures is made more plain by means of the following

TABLE.

Tenths	.5
Hundredths	.56
Thousandths	.567
Ten thousandths	.5678
Hundred thousandths, &c.	.56789

Thus, .5 is read five-tenths; .56 is read five-tenths and six hundredths, or fifty-six hundredths; .567 is read five-tenths, six hundredths, and seven-thousandths, or five hundred and sixty-seven thousandths; and so on, as in the table.

Ciphers to the right hand of decimals cause no difference in their value; for .5, .50, .500 are decimals of the same value, being each equal to $\frac{1}{2}$; that is, $.5 = \frac{5}{10}$, $.50 = \frac{50}{100}$, $.500 = \frac{500}{1000}$. But if ciphers are placed on the left hand of decimals, they diminish their value in a tenfold proportion; thus, .3, .03, .003, are three-tenths, three-hundredths, and three-thousandths, and answer to the vulgar fractions $\frac{3}{10}$, $\frac{3}{100}$, $\frac{3}{1000}$, respectively.

A whole number and decimal are thus expressed, 85.75, 85.04, &c.

REDUCTION OF DECIMALS.

By reduction we change vulgar fractions, and the lesser parts of coin, weight, measure, &c., into decimals, and find the value of any decimal given.

Because decimals increase their value towards the left hand, and decrease their value towards the right hand, in the same tenfold proportion with integers, or whole numbers, they may be annexed to whole numbers, and worked in all respects as whole numbers; hence, if simple arithmetic be well understood, there is little more to be learned than the placing of the separating point—the rule for which ought to be well attended to

1.—*To reduce a vulgar fraction to a decimal of an equal value.*

Rule.—Add a cipher, or ciphers, to the numerator, and divide by the denominator, the quotient will be the decimal required.

EXAMPLE.—Reduce $\frac{14}{32}$ to a decimal.

32)14.0000(.4375
128
120
96
240
224
160
160

Thus you may take any number of ciphers at pleasure, but their number will be best ascertained when the work is finished; then you must have as many decimal figures as you have taken annexed ciphers in dividing; and if there are not so many in the quotient, you must prefix ciphers to the left hand of it,—thus, $\frac{1.00000}{32} = .03125$.

Sometimes the quotient figures will repeat continually, as $\frac{2}{3}$, thus, $\frac{2.000}{3} = .666$, then it is called a repetend, and the last figure may be dashed or marked, to distinguish it from a terminate decimal.

Sometimes two, three, or more figures will repeat, as $\frac{12}{33}$, thus, $\frac{12.0000}{33} = .3636$; such are called compound repetends or circulates, and the first and last figure may be dashed or marked.

2.—*To reduce the lesser parts of coin, weights, measures, &c., to decimals.*

RULE.—Divide the least name by such number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same name, then divide by such number as will reduce it to the next greater, always annexing ciphers to the dividend, as occasion may require: thus proceed till it be reduced to the decimal of the required integer. Or, reduce the given parts to a simple quantity, by reducing them to the lowest name mentioned; annex ciphers thereto, and divide by such numbers as will reduce them to the name required. Or, reduce the given parts to a vulgar fraction, and that fraction to a decimal.

EXAMPLE 1.—Reduce 17s. 10½d. to the decimal of a pound sterling.

$\frac{10}{2} = .5 + 10\text{d.} = \frac{10.500}{12} = .875 + 17\text{s.} = \frac{17.87500}{20} = .89375$, the decimal required.

EXAMPLE 2.—Reduce 2 feet 9 inches to the decimal of a yard.

Vulgar fraction $\frac{9}{36}$, and $\frac{33.0000}{36} = .9166$ as required.

To find the value of any given decimal.

RULE.—Multiply the decimal given by the number of parts of the next inferior denomination, cutting off the decimals from the product; then multiply the remainder by the next inferior denomination; thus proceeding till you have brought the least known parts of the integer.

EXAMPLE 1.—Required the value of .89375 of a pound sterling.

.89375
20
17.87500
12
10.50000
2
1.00000 or, 17s. 10½d.

EXAMPLE 2.—Reduce .625 of a hundred weight to its proper terms.

$.625 \times 4 = 2.500 \times 28 = 14.000$, or 2 quarters and 14 lbs.

A TABLE OF RECIPROCALS,

FOR OBTAINING DECIMAL EQUIVALENTS.

No.	Recip.	No.	Recip.	No.	Recip.	No	Recip.	No.	Recip.
1	1.000000	51	.019607	101	.009900	151	.006623	201	.004975
2	.500000	52	.019231	102	.009803	152	.006579	202	.004951
3	.333333	53	.018868	103	.009709	153	.006536	203	.004927
4	.250000	54	.018519	104	.009616	154	.006494	204	.004901
5	.200000	55	.018182	105	.009523	155	.006451	205	.004879
6	.166667	56	.017857	106	.009433	156	.006411	206	.004855
7	.142857	57	.017543	107	.009345	157	.006370	207	.004831
8	.125000	58	.017242	108	.009260	158	.006329	208	.004807
9	.111111	59	.016949	109	.009174	159	.006290	209	.004785
10	.100000	60	.016667	110	.009091	160	.006250	210	.004762
11	.090901	61	.016393	111	.009010	161	.006211	211	.004740
12	.083333	62	.016129	112	.008928	162	.006172	212	.004716
13	.076923	63	.015873	113	.008850	163	.006135	213	.004695
14	.071428	64	.015625	114	.008771	164	.006097	214	.004673
15	.066667	65	.015385	115	.008695	165	.006061	215	.004651
16	.062500	66	.015151	116	.008620	166	.006025	216	.004629
17	.058823	67	.014925	117	.008548	167	.005988	217	.004609
18	.055556	68	.014705	118	.008475	168	.005952	218	.004588
19	.052632	69	.014492	119	.008403	169	.005917	219	.004566
20	.050000	70	.014285	120	.008333	170	.005882	220	.004546
21	.047620	71	.014085	121	.008264	171	.005847	221	.004525
22	.045455	72	.013889	122	.008196	172	.005813	222	.004505
23	.043078	73	.013698	123	.008130	173	.005781	223	.004485
24	.041667	74	.013513	124	.008065	174	.005748	224	.004465
25	.040000	75	.013333	125	.008000	175	.005715	225	.004444
26	.038462	76	.013158	126	.007936	176	.005682	226	.004425
27	.037038	77	.012987	127	.007875	177	.005650	227	.004406
28	.035715	78	.012820	128	.007812	178	.005618	228	.004386
29	.034483	79	.012659	129	.007752	179	.005586	229	.004366
30	.033333	80	.012500	130	.007693	180	.005556	230	.004348
31	.032259	81	.012346	131	.007634	181	.005524	231	.004329
32	.031250	82	.012195	132	.007576	182	.005495	232	.004311
33	.030303	83	.012048	133	.007519	183	.005464	233	.004292
34	.029412	84	.011904	134	.007463	184	.005434	234	.004273
35	.028572	85	.011765	135	.007408	185	.005406	235	.004256
36	.027778	86	.011628	136	.007352	186	.005376	236	.004238
37	.027028	87	.011494	137	.007299	187	.005347	237	.004220
38	.026316	88	.011364	138	.007247	188	.005320	238	.004201
39	.025642	89	.011235	139	.007195	189	.005292	239	.004184
40	.025000	90	.011111	140	.007143	190	.005264	240	.004167
41	.024390	91	.010989	141	.007093	191	.005235	241	.004150
42	.023809	92	.010870	142	.007042	192	.005208	242	.004132
43	.023255	93	.010753	143	.006994	193	.005182	243	.004116
44	.022727	94	.010639	144	.006944	194	.005155	244	.004098
45	.022222	95	.010527	145	.006896	195	.005129	245	.004081
46	.021739	96	.010417	146	.006850	196	.005102	246	.004065
47	.021276	97	.010310	147	.006802	197	.005076	247	.004048
48	.020833	98	.010204	148	.006756	198	.005051	248	.004033
49	.020408	99	.010101	149	.006712	199	.005026	249	.004016
50	.020000	100	.010000	150	.006667	200	.005000	250	.004000

The numbers in the table are the denominators of the fraction: hence, multiply the reciprocal of the denominator by the numerator of the fraction, and the product is the decimal equivalent.

Thus, suppose the decimal equivalent of 7-16ths be required:—

Reciprocal of 16 = .0625 × 7 = .4375 its decimal equivalent.

ADDITION OF DECIMALS.

RULE.—Arrange the numbers under each other, according to their several values; find the sum, as in addition of whole numbers, and cut off for decimals as many figures to the right hand as there are decimals in any one of the given numbers.

EXAMPLE,—What is the sum of 23.45, 7.849, 543.2, 8.6234, 253.004?

23.45
7.849
543.2
8.6234
253.004
836.1264

If any of the decimals be repetends, continue them beyond the others, and make them end together; then, in adding, increase the sum of the first column by as many units as there are nines therein; as,

.75
.6666
.8888
.875
.4444
3.6250

Here the first sum, 18, contains two nines; therefore two added to 18 = 20. The rest of the work is the same as usual in others; the repetend is 0, so the sum is finite.

If some of the decimals be repetends, and others circulates, continue them both beyond those that are finite, and till their periods end together; then to the sum of the first column add as many as would arise to carry to it if they were continued farther; so will you have a circulate in the sum. Thus,

2.5
3.666666
7.696969
14.372372
28.236008

. The repetend of .6, the circulate of 69 and .372, continued till their periods end together. It may easily be observed that there would be one to carry to the first column if it were carried any farther.

NOTE.—It is not always necessary to attend to the rule for repetends and circulates; three or four decimal figures, according to the rule, being sufficiently near the truth for common calculations.

SUBTRACTION OF DECIMALS.

RULE.—Place the numbers directly under each other according to their several values, subtract as in whole numbers, and cut off for decimals, as in addition.

EXAMPLE.—Subtract 35.87043 from 132.005.

132.005 + 10
35.87043
96.13457 ·

If both be single repetends, make them end together; and if there be occasion to borrow at the first figure, borrow 9 only instead of 10;

thus,—.8333 + 9
.6666
.1666

If both be circulates, or one a repetend and the other a circulate, continue both till their periods end together; then if there should be occasion to borrow at the following figure, were they continued that figure farther, carry one to the first figure; and if the numbers be in different denominations, reduce them till they be alike.

Subtract $\frac{8}{9}\frac{3}{9}\frac{4}{9}$ from $1\frac{2}{3}$; thus,

1.666666
.834834 + 1
.831831

MULTIPLICATION OF DECIMALS.

RULE.—Place the factors under each other, and multiply them together, as in whole numbers; then point off as many figures from the product *(counting from right to left)* as there are decimal places in both factors; observing, if there be not enough, to annex as many ciphers to the left hand of the product as will supply the deficiency.

EXAMPLE.—Multiply .4375 by .125.

.4375
.125
21875
8750
4375
.0546875

Here the product of .4375 by .125 is .0546875; but as there are three places of decimals in the multiplier, and four in the multiplicand, a cipher must be added on the left hand of the product to reduce it to its proper terms.

To multiply a repetend by a single figure, add 1 to the first product for every 9 therein, so will you have a repetend in the product; and if there be several figures in the multiplier, do so with each product, and continue them till they end together; then add them as so many repetends.

If the multiplicand be a circulate, consider the increase that would arise to the first product if the multiplicand were continued farther: thus do with each product, make them end together, and add them by the rule for adding circulates.

To contract the operation so as to retain only as many decimals in the product as may be thought necessary.

RULE.—Place the unit figure of the multiplier under that figure of the multiplicand whose place is the last to be retained in the product, and dispose of the rest so that they may all stand in contrary order to that in which they are usually placed.

Then, in multiplying, reject all the figures to the right hand of the multiplying digit, and set down the product so that the right hand figures may fall in a straight line under each other; observing to increase the first figure of every line with what would arise, by carrying 1 from 5 to 14,—2 from 15 to 24,—3 from 25 to 34, &c., from the product of the two preceding figures when you begin to multiply; and the sum will be the product required.

EXAMPLE.—Multiply 27.14986 by 92.41035.

Common way.		*Contracted way.*
27.14986		27.14986
92.41035		53014.29
13574930		24434874
8144958		542997
2714986		108599
108599 44		2715
542997 2		81
24434874		14
2508.9280	650510	2508.9280

DIVISION OF DECIMALS.

RULE.—Prepare your decimals as directed for multiplication, divide as in whole numbers, cut off as many figures for decimals in the quotient as the number in the dividend exceeds the number in the divisor, namely, make the number of decimal figures in the divisor and quotient together equal to the number in the dividend.

EXAMPLE.—Divide 173.5425 by 3.75.

```
3.75)173.5425(46.278
     1500
     ----
     2354
     2250
     ----
     1042
      750
     ----
     2925
     2625
     ----
     3000
     3000
     ====
```

Although you may take additional ciphers at pleasure, care must be had in reckoning the number taken in dividing for decimals in the dividend; and if you put the decimal point in the quotient at any part of the operation, continuing the operation afterwards will not cause the point to be removed.

If there should not be so many figures in the quotient as there should be decimals, prefix ciphers on the left hand to make up the number.

EXAMPLE.—Divide 1.4850 by 247.5.

Thus, $\frac{1.4850}{247.5} = .006$. And if there be not as many decimal figures in the dividend as in the divisor, you may annex a sufficient number of ciphers; and if there be not a remainder, you must add ciphers to the right hand of the quotient till you have taken as many in the dividend as will make the decimal figures therein equal to those in the divisor: thus,—

$$\frac{14856}{2.476} = 6000.$$

A TABLE

Of the fractional parts of an inch when divided into thirty-two parts: likewise a foot of twelve inches reduced to decimals.

Parts.	*Decimals.*	*Parts.*	*Decimals.*	*Parts of a foot.*	*Decimals.*
$\frac{7}{8}$ & $\frac{3}{32}$	= .96875	$\frac{3}{8}$ & $\frac{1}{32}$	= .46875	11	= .9166
$\frac{7}{8}$ & $\frac{1}{16}$	= .9375	$\frac{3}{8}$ & $\frac{1}{16}$	= .4375	10	= .8333
$\frac{7}{8}$ & $\frac{1}{32}$	= .90625	$\frac{3}{8}$ & $\frac{1}{32}$	= .40625	9	= .75
$\frac{7}{8}$	= .875	$\frac{3}{8}$	= .375	8	= .6666
$\frac{3}{4}$ & $\frac{3}{32}$	= .84375	$\frac{1}{4}$ & $\frac{3}{32}$	= .34375	7	= .5833
$\frac{3}{4}$ & $\frac{1}{16}$	= .8125	$\frac{1}{4}$ & $\frac{1}{16}$	= .3125	6	= .5
$\frac{3}{4}$ & $\frac{1}{32}$	= .78125	$\frac{1}{4}$ & $\frac{1}{32}$	= .28125	5	= .4166
$\frac{3}{4}$	= .75	$\frac{1}{4}$	= .25	4	= .3333
$\frac{5}{8}$ & $\frac{3}{32}$	= .71875	$\frac{1}{8}$ & $\frac{3}{32}$	= .21875	3	= .25
$\frac{5}{8}$ & $\frac{1}{16}$	= .6875	$\frac{1}{8}$ & $\frac{1}{16}$	= .1875	2	= .1666
$\frac{5}{8}$ & $\frac{1}{32}$	= .65625	$\frac{1}{8}$ & $\frac{1}{32}$	= .15625	1	= .0833
$\frac{5}{8}$	= .625	$\frac{1}{8}$	= .125	$\frac{7}{8}$	= .17291
$\frac{1}{2}$ & $\frac{1}{32}$	= .59375	$\frac{3}{32}$	= .09375	$\frac{3}{4}$	= .0625
$\frac{1}{2}$ & $\frac{1}{16}$	= .5625	$\frac{1}{16}$	= .0625	$\frac{5}{8}$	= .0528
$\frac{1}{2}$ & $\frac{1}{32}$	= .53125	$\frac{1}{32}$	= .03125	$\frac{1}{2}$	= .04166
$\frac{1}{2}$	= .5			$\frac{3}{8}$	= .03125
				$\frac{1}{4}$	= .02083
				$\frac{1}{8}$	= .01041

The utility of this table will appear evident by means of the following example:—

Suppose a board, or plate, to be $30\frac{1}{4}$ inches long, $8\frac{5}{8}$ inches broad, and $\frac{3}{8}$ and $\frac{1}{16}$ of an inch in thickness; required its contents in cubic inches.

$30.25 \times 8.625 = 260.90625 \times .4375 = 114.146$, &c. cubic inches.

OF THE SQUARE ROOT.

When a number is multiplied by itself, as 6 × 6, or 9 × 9, &c., it produces the square or second power of that number; and the number itself is called the root of that square.

A root consisting of a single figure is found by inspection of the following table:—

Root	1	2	3	4	5	6	7	8	9
Squares	1	4	9	16	25	36	49	64	81
Cubes	1	8	27	64	125	216	343	512	729

To extract or find the square root of any number which consists of more figures than one.

RULE.—Make a point or dot over every second figure, commencing at the right hand, by which the given square will be pointed into periods of two figures each, except the first or left-hand period, which will sometimes have but one.

The unit figure must always be the latter figure in the period; for the decimal point must be between the periods, and not in the middle of a period.

Find the greatest root in the first period, which write in the quotient or root, and the square thereof under the same period; subtract therefrom, and to the remainder annex the next period for a dividend.

Double the quotient for a divisor; see how often the divisor is contained in the dividend, with this consideration, that the answer must be the unit's figure of the divisor.

Write the answer in the quotient, also in the unit place of the divisor; then multiply the divisor, so completed, by the last quotient figure; write the product under the dividend, and subtract therefrom; to the remainder annex the next period for a new dividend.

Thus proceed with every period; and if there be still a remainder, annex pairs of ciphers for additional periods, till you have a competent number of decimals in the root.

Vulgar fractions, &c., may be reduced to decimals.

The periods which are whole numbers give whole numbers, and decimal periods give decimals in the root.

EXAMPLE 1.—What is the square root of 76176?

```
 7̇6̇1̇7̇6(276, or 276 × 276 = 76176.
 4
47)361
   329
  ----
546)3276
   3276
  ====
```

EXAMPLE 2.—Required the root of .75.

```
  .7̇5̇(.866 or .866² + 44 = .75
  64
 ----
166)1100
    966
   ----
1726)10400
     10356
    -----
        44
    =====
```

EXAMPLE 3.—Required the root of .00854.

```
 .0̇0̇8̇5̇4(.029 or .029
   4          .29
 ----       -----
49)454       261
   441        58
 ----       -----
   13        841
 ====      + 13
           -----
           .00854
           =====
```

OF THE CUBE ROOT.

When a square is multiplied again by its root, as $6 \times 6 \times 6$, it produces the cube or third power of that root.

Single cubes are found by inspection of the preceding table.

To extract the root of any number that consists of more than one figure.

RULE.—Point the given cube into periods of three figures, and so that the unit figure be the last in its period; then from the first period subtract the greatest cube it contains; put the root as a quotient, and to the remainder bring down the next period for a dividend.

Find a divisor by multiplying the square of the root by 300; see how often it is contained in the dividend; and the answer gives the next figure in the root.

Multiply the divisor by the last figure in the root. Multiply all the figures in the root by 30, except the last; and that product by the square of the last. Cube the last figure in the root; add these three last found numbers together, and subtract this sum from the dividend; to the remainder bring down the next period for a new dividend, and proceed as before.

EXAMPLE.—Required the cube root of 444194947.

444194947(763
343
$7 \times 7 \times 300 = 14700)$101194
95976
$76 \times 76 \times 300 = 1732800)$5218947
5218947

1. Divisor 14700		2. Divisor 1732800	
	6		3
	88200		5198400
$7 \times 30 \times 36 =$	7560	$76 \times 30 \times 9 =$	20520
$6 \times 6 \times 6 =$	216	$3 \times 3 \times 3 =$	27
	95976		5218947

Besides the preceding, there is another, and, perhaps, a better way of extracting the cube root, and which we shall attempt to render as intelligible as possible, by an explanation of the following example:—

EXAMPLE.—Required the cube root of 926859375.

1st Cipher.	*2nd Cipher.*	
0	0	926859375(975
9	81	729
9	81	197859
9	162	183673
18	24300	14186375
9	1939	14186375
270	26239	
7	1988	
277	2822700	
7	14575	
284	2837275	
7		
2910		
5		
2915		

After having divided the number into periods of three figures each as before, place before it two ciphers, at moderate distances from each other, and from the number itself, as represented in the example; then find, by a reference to the table, page 32, the nearest cube contained in 926, the first period, and place its root, which is 9, in the quotient, as the first figure of the required root. Place it also under the first cipher, and by going through the process of addition, we obtain 9. Multiply this by 9, and place the product under the second cipher. By again going through the form of addition we get 81, which being multiplied by 9, becomes 729. This is placed under the first period of figures, 926, and subtracted from it, and to the remainder the second period, 859, is annexed. Then recommencing at the column of the first cipher, we again place a 9, and add up. To the sum we add another 9, and obtain 27. We now multiply the 18 by 9, and place the product 162 under the 81 of the second column, and by addition we obtain

243. We now turn to the first column, and annex one cipher to the 27, making it 270; and in a similar manner annex two ciphers to the 243 of the second column. All this is done preparatory to finding the second figure of the quotient, or of the required root.

To find that figure we divide the number 197859 of the third column by 24300 of the second column. The quotient would appear to be 8: this, however, is found on trial to be too large, and we therefore take 7, which answers. We add this 7 to the first column, and multiply the sum 277 by 7, placing the product 1939 in the second column. Then, by adding up, we obtain 26239, the product of which by 7 we place in the third column and subtract, and to the remainder we annex the last period of figures 375. Recommencing at the first column, we add 7 to the 277, and to the sum 284 we add 7 again. We now multiply the sum 284 by 7, and place the product in the second column and add up. Then to the 291 in the first column we annex one cipher, and to the 28227 in the second column two ciphers.

To find the third figure of the root we divide the number 14186375 in the third column by the 2822700 in the second column, and the quotient is found to be 5. This we add to the first column, and multiply the sum 2915 by 5, and place the product under the 2822700 of the second column. Upon adding we obtain 2837275, whose product by 5 is placed under the 14186375 of the third column, and, being exactly equal to it, there is no remainder upon subtracting, consequently the work is finished, and 975 is the required cube root.

N.B.—The above method is not only useful for extracting the cube root, but also for that of any other root, attention being paid to the following directions:—

Instead of dividing the number whose root is to be extracted into periods of three figures each, we divide it into periods of as many figures each as correspond to the order of the root, as, for example, four figures for the fourth root, five for the fifth, &c.; but the number of ciphers which we employ must be one less than that which corresponds to the order of the root, as three ciphers for the fourth root, and four for the fifth root. It must be borne in mind, too, that every new figure which we place in the quotient must be added to the first column as many times as correspond to the order of the root, and that the number of products added to the second column be one less than the above number, and that added to the third two less, and so on.

Lastly, before finding a new figure for the quotient, we annex one cipher to the number in the first column, two to that in the second, three to that in the third, and so on, until we arrive at the last column, where, instead of annexing ciphers, we bring down the numbers that make up the next period.

If, after extracting the root, we have a remainder, we can continue the quotient to decimals, by annexing to the remainder as many ciphers as there are figures in a period, and then proceeding as before; and if the number whose cube root is to be extracted consist of a whole number and a decimal, we divide it into periods by commencing at the decimal point, and proceeding towards the left hand to divide the whole number, and towards the right to divide the decimal; and if the decimal do not contain a sufficient number of figures to make up the last period, we supply the deficiency with ciphers.

The following example will, perhaps, make the subject a little more plain:—

EXAMPLE.—Required the fourth root of 285762.321.

1st Cipher.	2nd Cipher.	3rd Cipher.	
0	0	0	285762.3210(23.12
2	4	8	16
2	4	8	125762
2	8	24	119841
4	12	32000	··59213210
2	12	7947	48986321
6	2400	39947	102268890000
2	249	8721	98739268336
80	2649	48668000	··3529621664
3	258	318321	
83	2907	48986321	
3	267	319243	
86	317400	49305564000	
3	921	64070168	
89	318321	49369634168	
3	922		
920	319243		
1	923		
921	32016600		
1	18484		
922	32035084		
1			
923			
1			
9240			
2			
9242			

Involution and Evolution of numbers are very conveniently performed upon the *Engineer's Slide Rule*, for when the slide is set straight at both ends, C is a line of squares, and D a line of roots; consequently, against any number upon D is its square upon C, and against any number upon C is its root upon D.

EXAMPLE 1.—What is the square of 16?

Opposite 16 upon D is 256, the square number upon C.

EXAMPLE 2.—Required the square root of 625.

Opposite 625 upon C is 25 upon D, the root required.

The cube root is performed by inverting the slide, and setting the number to be cubed upon B to the same number upon D, and against 1 or 10 upon D is the cube number upon B. Also, set the cube number upon B to 1 or 10 upon D, and where two numbers of equal value meet upon the lines B and D is the root required.

EXAMPLE 1.—Required the cube of 9.

Set 9 upon B to 9 upon D, and against 10 upon D is 729 upon B.

EXAMPLE 2.—Required the cube root of 343.

Set 343 upon B to 10 upon D, and against 7 upon B is 7 upon D, the root required.

These lines also serve to multiply the square of any number, any number of times: thus,—

To find the product of 6 times 6, multiplied by 3.

Set 3 upon B to 6 upon D, and against 10 upon D, is 108 upon B.

To find the root of a number, consisting of integers and decimals.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given; the sum will be the root of the number required, correct in all cases of the square root to 3 places of decimals, and in the cube root to 7.

EXAMPLE 1.—Required the square root of 60.2.

$\sqrt{61} = 7.8102$
$\sqrt{60} = 7.7459$
difference .0643
× .2
= .01286
+ 7.7459
$\sqrt{60.2} = 7.75876$ as required, correct to 3 places of decimals.

EXAMPLE 2.—Required the cube root of 843.75.

$\sqrt[3]{844} = 9.4503$
$\sqrt[3]{843} = 9.4466$
difference .0037
× .75
= .002775
+ 9.4466
$\sqrt[3]{843.75} = 9.449375$ as required.

If the square root is required correct to more places of decimals, the following rule is correct to 7 places:

Multiply the root of the nearest integer number by twice the difference between that and the given number, and divide the product by 3 times the integer number added to the given number; and the quotient added to the root of the integer number will be the root of the given number nearly. Then, the root of 60.2 will stand thus,

$\sqrt{60}$ 7.7459
× .4 2 × 2

$60 \times 3 = 180 + 60.2 = 240.2)3.09836(.01289 + 7.7459 = 7.75889$ the root required.
2402

6963
4804

21596
19216

23800

If the number consist wholly of decimals, the root will be decimals also.

PRACTICAL GEOMETRY.

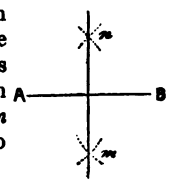
Geometry is the science which treats of that species of quantity called magnitude, as represented by lines, surfaces, and solids.

Practical Geometry is that art by which we are enabled to turn the rules of the science to a practical account.

PROBLEM I.

To divide a given line into two equal parts.

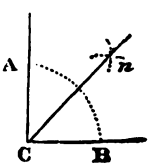
From A and B as centres, with any distance greater than half the length of the line, describe arcs cutting each other in *m* and *n*; then a line drawn through the points *m* and *n* will divide the line into two equal parts, as required.



PROBLEM II.

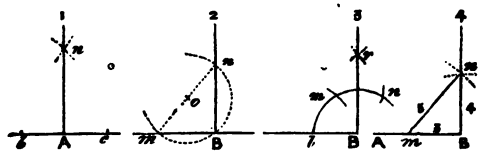
To divide a given angle into two equal parts.

From the point C as a centre, with any distance at pleasure, describe the arc A B; and from A and B as centres, with the same or any other convenient distance, describe arcs cutting each other in *n*; then a line drawn from the point C, through *n*, will divide the angle as required.



PROBLEM III.

From any given point in a right line, to erect a perpendicular.



1.—On each side of the point A, take equal distances, as *b* A, A *c*; from *b* and *c*, as centres, with any radius greater than *b* A or *c* A, describe arcs cutting each other in *n*; then will a line drawn from the point A through *n* be the perpendicular required.

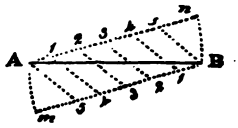
2.—Take any point *o*, and with *o* as centre, and *o* B as radius, describe the arc *m* B *n*, cutting the line in *m* and B; draw a line from *m* through the centre *o*, and continue it until it cut the opposite side of the arc in *n*; then the line which joins *m* and B is the perpendicular required.

3.—With the point B as centre, and with any radius, describe the arc *l m n*, cutting the line in *l*; with *l* as centre, and the same radius, cut the arc in *m*; and with *m* as centre, and the same radius, cut the arc again in *n*. Now, with *m* and *n* as centres, and with any radius, describe arcs cutting each other in *r*, then the line joining *r* and B is the perpendicular required.

4.—From the point B, on the line A B, take three equal parts (as feet, inches, &c.) to *m*; and from *m* and B as centres, describe arcs cutting each other in *n*, making the distance from B to *n* four parts, and from *m* to *n* five parts, then will the line B *n* be the perpendicular required.

PROBLEM IV.

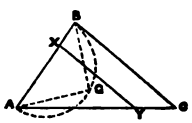
To divide a right line into any number of equal parts.



Let A B be the line that is to be divided; then at the point A draw a line making any angle with the line A B, and at B draw another line parallel to it. Upon each of these lines, beginning at the points A and B, cut off as many equal parts as you require the line A B to be divided into, as A 1, 1 2, 2 3, &c., B 1, 1 2, 2 3, &c; then draw lines joining the points A and 5, 1 and 4, 2 and 3, &c., and the lines so drawn will cut A B into the required number of equal parts.

PROBLEM V.

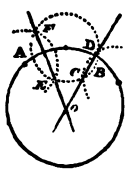
To divide a triangle into two equal parts, and still retain its original form.



Let A B C be the given triangle to be divided, bisect one of its sides as A B, and describe the semicircle A G B; bisect the semicircle in G, and at a distance from A, equal to A G or B G, draw the line $x\ y$, parallel to B C, which is the line of equal division as required.

PROBLEM VI.

Through any three points out of a right line to describe the circumference of a circle.



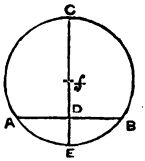
From the middle point as a centre, with any convenient distance, describe the circle, or arcs of a circle, as A and B, and from the other points, with the same distance, describe arcs cutting the circle in C D and E F; draw lines through C D and E F, and where

they intersect each other at *o* is the centre of the circle required.

PROBLEM VII.

To find the centre of a given circle.

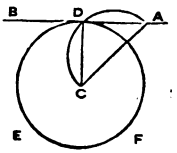
Draw any chord A B, bisect it in D, and through D draw E C perpendicular to A B; then bisect E C, and the point of section *f* will be the centre of the circle.



PROBLEM VIII.

From a given point to draw a tangent to a circle.

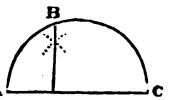
Let A be the point from which it is required to draw a tangent to the circle D E F. Join A and the centre C, and upon the line A C describe the semicircle A D C, then through D, the point at which the circles intersect, draw the line A B, which will be the tangent required.



PROBLEM IX.

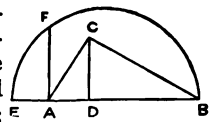
To find a mean proportional between two given right lines, or the side of a square equal to a given rectangle.

Upon a right line as a diameter equal to both given lines, describe the semicircle A B C, and where the two lines meet, or between their respective lengths, erect a perpendicular to the semicircle at B, and the perpendicular will be the mean proportion or side of the required square, equal to the given rectangle.



PROBLEM X.

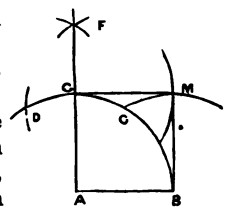
To find the side of a square which shall be equal in area to a given triangle.



Let A B C be the given triangle. From C let fall C D perpendicular to A B, and produce the line B A to E, making A E equal to half the perpendicular C D; then upon E B describe the semicircle E F B, and from the point A erect a perpendicular cutting the circle in F; then A F will be the side required.

PROBLEM XI.

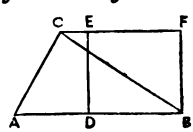
Upon a given right line to construct a square.



Let A B be the line upon which it is required to construct a square. With A as centre, and A B as radius, describe the arc B C D; with B as centre, and the same radius, cut the arc in C; and with C as centre, and the same radius, cut the arc again in D; then with C and D as centres, and with equal radii, describe arcs cutting each other in F, and from F draw F A, cutting the circle in G. Then with G and B as centres, and the distance A B as radius, describe arcs cutting each other in M; join G M and B M, and the figure G M B A is the required square.

PROBLEM XII.

To make a rectangle equal to a given triangle.

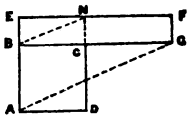


Let A B C be a triangle, to which it is required to make a rectangle equal. Bisect A B in D, and at D erect a perpendicular; from B draw a line parallel to D E, and from C

draw a line parallel to A B; then the figure D E F B is the rectangle required.

PROBLEM XIII.

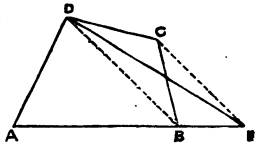
To produce a rectangle equal to a given square.



Suppose A B C and D be the given square, also B E one end of the required rectangle, draw E F parallel to B C, join B N, continue the side of the square B C, and draw the line A G parallel with B N, until it intersects at G, then B G is the side of the rectangle required.

PROBLEM XIV.

To make a triangle equal to a given qualrilateral figure.

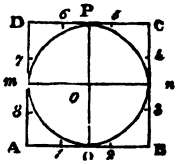


Let A B C D be the given qualrilateral figure.

Join D and B, and from C draw C E parallel to D B; produce A B to E, and join D and E; then the triangle A D E is the triangle required.

PROBLEM XV.

To circumscribe a square about a given circle.



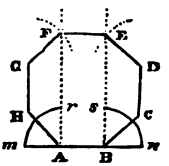
Draw two diameters at right angles as *m n* and O P; from *m n*, O P, as centres, with the radius of the circle, describe arcs cutting each other in A B C and D; join A B, B C, C D, D A, and A B C D will be the square required.

And from A as a centre, with the distance A *o*, cut

the lines A B, A D, in 2 and 7; from B as a centre cut the lines B A, B C, in 1 and 4; from C as a centre cut the lines C B, C D, in 3 and 6; and from D as a centre cut the lines D C, D A, in 5 and 8; join 1, 8; 2, 3; 4, 5; and 6, 7; and 1, 2, 3, 4, 5, 6, 7, 8, will be a regular octagon.

PROBLEM XVI.

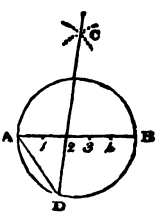
Upon a right line to describe an octagon.



On the extremities of one side A B, erect the perpendiculars A F and B E; continue the line A B to A *m* and B *n*, forming the angles *m* A *r* and *n* B *s*; bisect the angles with the lines A H and B C; make each of those lines equal to A B; make H G and C D the same length, and parallel to A F and B E; from G and D as centres with the radius A B, describe arcs cutting A F and B E; join G F, F E, and E D, then A B C D E F G H will be the octagon required.

PROBLEM XVII.

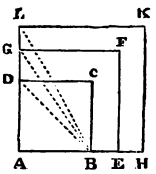
In a given circle to inscribe any regular polgon.



Divide the diameter A B into as many equal parts as the polygon is required to have sides; from A and B as centres, with the distance A B, describe arcs cutting each other in C; draw a line through the second division, meeting the circumference at D; join A D, and it will be the side of the polygon required.

PROBLEM XVIII.

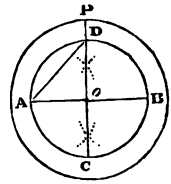
To find the side of a square that shall be any number of times the area of a given square.



Let A B C D be the given square, then will the diagonal B D be the side of a square A E F G, double in area to the given square A B C D; and if the diagonal be drawn from B to G, it will be the side of a square A H K L, three times the area of the square A B C D, or the diagonal B L will equal the side of a square four times the area of the square A B C D, &c.

PROBLEM XIX.

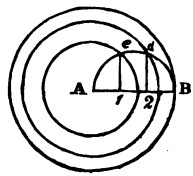
To find the diameter of a circle that shall be any number of times the area of a given circle.



Let A B C D be the given circle; draw the two diameters A B and C D at right angles to each other, and the chord A D will be the radius of the circle *o* P, twice the area of the given circle nearly; and half the chord will be the radius of a circle that will contain half the area, &c.

PROBLEM XX.

To divide a given circle into any number of co-centric parts equal to each other.

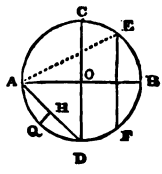


Upon the radius A B describe the semicircle A *e d* B; divide A B into the proposed number of equal parts, as 1, 2, &c.; erect the perpendiculars 1 *e*, 2 *d*, &c., meeting the semicircle in *e* and *d*; then from the centre A, and radii A *e* A *d*, &c., describe circles; so shall the circle be divided into the proposed number of equal parts as required.

PROBLEM XXI.

To find the side of a square nearly equal in area to a given circle.

Draw the two diameters A B and C D at right angles to each other, bisect the radius O C by a line from one end of the diameter at A, meeting the circumference in E, then will the line A E be the side of a square nearly equal in area to the given circle.



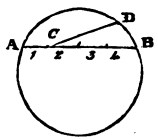
And if the line E F be drawn parallel to C D, it will be $\frac{1}{4}$ of the circumference nearly.

Or three times the diameter A B or C D, and once the versed sine Q H, of the angle A O D, will be the circumference nearly.

PROBLEM XXII.

To find a right line that shall be nearly equal to any given arc of a circle.

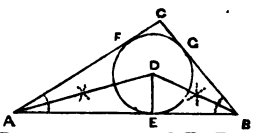
Divide the chord A B into four equal parts, set one part on the circumference from B to D, draw a line from C, the first division on the chord; and twice the length of the line C D will be the length of the arc nearly.



PROBLEM XXIII.

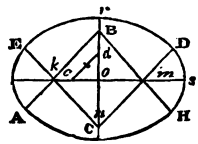
To describe the largest possible circle in a triangle.

Let A B C be a triangle. Bisect the two angles A and B, (by Problem II,) and from D, where the lines A D and B D meet, draw D E perpendicular to A B; then, with D as centre, and D E as radius, describe the circle E F G, which is the one required.



PROBLEM XXIV.

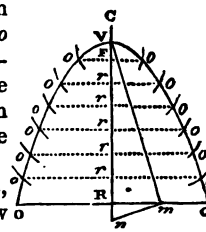
To describe an ellipsis, the transverse and conjugate diameters being given.



From *o*, as a centre, with the difference of the transverse and conjugate semi-diameters, set off *o c* and *o d*; draw the diagonal *c d*, and continue the line *o c* to *k*, by the addition of half the diagonal *c d*, then will the distance *o k* be the radius of the centres that will describe the ellipsis; draw the lines A B, C D, C E, and B H, cutting the semi-diameters of the ellipsis in the centres *k* B *m n*; then with the radius *m s*, and with *k* and *m* as centres, describe the arcs D H and A E; also, with the radius *n r*, and with *n* and B as centres, describe the arcs E D and A H, and the figure A E D H will be the ellipsis required.

PROBLEM XXV.

To describe a parabola, any ordinate to the axe and its abscissa being given.



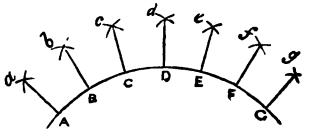
Let V R and R *o* be the given abscissa and ordinate; bisect R *o* in *m*, join V *m*, and draw *m n* perpendicular to it, meeting the axe in *n*; make V C and V F each equal to R *n*, then will F be the focus of the curve.

Take any number of points, *r*, *r*, &c., in the axis, and draw the double ordinates of an indefinite length.

From F, as a centre, with the radii C F, C *r*, &c., describe arcs cutting the corresponding ordinates in the points *o o o o*, &c., and the curve *o* V *o* drawn through all the points of intersection, will be the parabola required.

PROBLEM XXVI.

To draw at the circumference of a circle lines tending towards the centre when the centre is inaccessible.

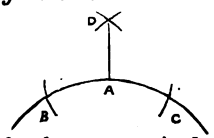


Mark off upon any portion of the circumference any number of equal parts, and with any radius greater than the length of one division, but less than that of two, and with the centres A, B, C, D, &c., describe arcs cutting each other in *b*, *c*, *d*, &c.; then the required lines may be drawn by joining *a* A, *b* B, *c* C, and so on.

To draw the end lines a A, *g* G.

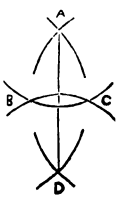
With the distance A *b* as radius, and with the centres B and F, describe the arcs *a* and *g*; then, with the distance B *b* as radius, and the centres A and G, describe arcs cutting the former ones, and at the points of intersection *a* and *g* draw A *a* and *g* G, which will be the required straight lines.

From any given point in the circumference, (as A *in the annexed figure,) to draw a line tending towards the centre.*



With A as centre, and with any radius, cut the circle in B and C; then, with B and C as centres and a radius greater than the former, describe arcs cutting each other in D; join D and A, and the line D A will be the one required.

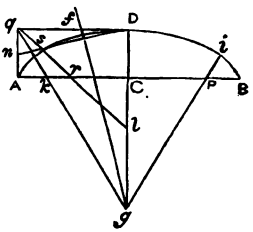
To draw from a point, without the circumference, a line tending towards the centre.



Let A be the given point. With A as centre, and with any convenient radius, describe an arc cutting the circumference in B and C; with B and C as centres, and the distance B A as radius, describe arcs cutting each other in A and D; then join A and D, and the line so drawn will be the one required.

PROBLEM XXVII.

To describe an elliptical arc, the width and rise of span being given.



Bisect the chord or width of span A B, and at the point of section C erect a perpendicular C D equal to the height of span; erect a perpendicular also at A, making A *q* equal to C D; join *q* and D, and bisect A *q* in *n*, and A C in *r*; join *n* and D, and from *q* through *r* draw the line *q l*, meeting the line D C produced. Now, bisect the line *s* D in *f*, and at the point of section erect at right angles the line *f g*, also meeting the line D C produced, join *g* and *q*, and the line so drawn will cut the line A B in *k*; make C P equal to C *k*, and through P draw the line *g i*; then, with *g* as centre and *g* D as radius, describe the arc *s* D *i*, and with *k* and P as centres and *k* A and P B as radii, describe the arcs A *s* and B *i*; the construction of the arch will then be completed.

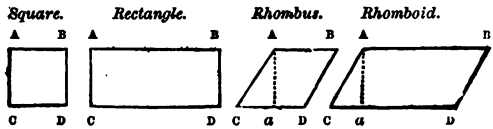
MENSURATION.

Mensuration is the method of calculating the comparative magnitudes of figures; and it is divided into two parts,—Mensuration of Superficies or Surfaces, and Mensuration of Solids.

The magnitude of a surface is called its area, and is the space enclosed between its boundary lines.

The magnitude of a body is called its solid contents, and is expressed in cubic feet, inches, &c.

MENSURATION OF SUPERFICIES.



A SQUARE is a quadrilateral figure which has all its sides equal, and all its angles right angles.

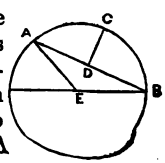
A RECTANGLE is a four-sided figure which has its angles, right angles, and its opposite sides parallel.

A RHOMBUS is a parallelogram whose sides are equal, but whose angles are not right angles.

A RHOMBOID is a parallelogram whose adjacent sides are unequal, aud whose angles are not right angles.

A TRAPEZOID is a four-sided figure which has but two of its sides parallel.

A CIRCLE is a figure bounded by one line called the circumference; and is such, that all lines drawn to the circumference from a certain point within the figure called the centre are equal to each other. Any of these lines is called



a radius; and a line drawn through the centre, terminating both ways in the circumference, is called a diameter. The portion of circle cut off by a diameter is called a semicircle.

An Arc of a circle is any portion of the circumference.

A Segment of a circle is a figure contained by an arc and its chord.

A Versed Sine is a line drawn from the middle of a chord perpendicular to the circumference.

A Sector of a circle is a figure contained by two radii and an arc, as A C B E.

PROBLEM I.

To find the area of any parallelogram.

Rule.—Multiply the length by the perpendicular height, and the product will be the area.

Example.—Required the area of a rhomboid whose length A B = 20.5, and perpendicular height *a* A = 11.75.

$$20.5 \times 11.75 = 240.875 \text{ the area.}$$

Note.—In a square, or rectangle, the perpendicular height is the breadth: therefore, to find the areas of a square and rectangle, multiply the length by the breadth.

PROBLEM II.

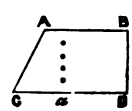
To find the area of a trapezoid.

Rule.—Add together the two parallel sides, multiply their sum by the breadth or height, and half the product is the area.

Example.—Required the area of a trapezoid whose sides A B and C D are 14.5 and 10.25, and breadth, *a* A, = 7.25.

$$\frac{14.5 + 10.25}{2} \times 7.25 = 89.71875$$

the area.



PROBLEM III.

To find the area of a triangle.

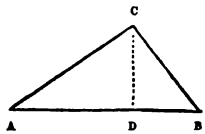
RULE.—Multiply one of its sides as a base by a perpendicular let fall from the opposite angle, and take half the product for the area.

Or, from half the sum of the three sides subtract each side separately, and multiply the three remainders so obtained and the half sum together, and the square root of the product will be the area.

EXAMPLE 1.—Required the area of a triangle A B C, whose base A B = 16.5, and perpendicular D C = 10.25.

$$\frac{16.5 \times 10.25}{2} = 84.5625$$

the area.



EXAMPLE 2.—What is the area of that triangle whose three sides are 8, 12, and 16 respectively?

$$\frac{8 + 12 + 16}{2} = 18,$$ the half sum of the sides;

then,	18	18	18	
	8	12	16	
	10	6	2	and $\sqrt{18 \times 10 \times 6 \times 2} = 46.47$

the area.

PROBLEM IV.

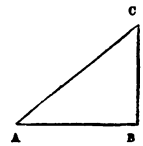
If any two sides of a right-angled triangle be given, the third side may be found by the following rules.

1.—To the square of the base add the square of the perpendicular; and the square root of the sum will be the hypotenuse or longest side.

2.—Multiply the sum of the hypotenuse, and one side by their difference; and the square root of the product will be the other side.

EXAMPLE 1.—Given the base A B = 16, and perpendicular B C = 12; required the length of the hypotenuse A C.

$\sqrt{16^2 + 12^2} = 20$ the length of the hypotenuse A C.



EXAMPLE 2.—Given the base A B = 16, and hypotenuse A C = 20; required the length of the perpendicular B C.

$\sqrt{20 + 16 \times 4} = 12$, length of the perpendicular B C.

NOTE.—The diagonal line, or hypotenuse in a square, is equal to the square root of twice the square of the side. And the side of a square is equal to the square root of half the square of its diagonal.

Thus, suppose each side of a square equal 12 feet:—

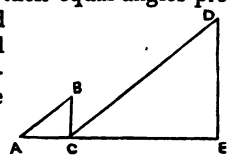
$12^2 \times 2 = \sqrt{288} = 16.9705$ feet, the diagonal. Or,

$\frac{16.9705^2}{2} = \sqrt{144} = 12$ feet, the length of each side.

Similar triangles, or those which are equi-angular to each other, have the sides about their equal angles proportional; thus, in the annexed figure the triangles A B C and C D E are similar, and, therefore, have the sides about the equal angles proportional,

AC : BC :: CE : DE;

AB : BC :: CD : DE, &c.



The utility, then, of the above triangles for practical purposes, as, for instance, ascertaining the heights of buildings, &c., will be seen from the following:—

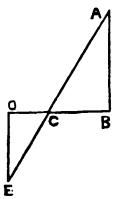
Suppose D E to be an eminence, of which it is required to find the height, and E C the length of the *shadow cast* by the sun; then, in order to find D E,

we may erect perpendicularly at C a pole of any known length, as B C, and after measuring the length of its shadow A C, state—as the length of the pole's shadow is to the height of the pole itself, so is the length of the shadow of D E to the height of D E ; or,

As AC : CB :: CE : ED;

and supposing A C = 6 feet, B C = 4 feet, and C E = 30 feet, then E D would be 20 feet.

Again, supposing we wished to find the distance between two objects A and B ; draw D B of any length at right angles to A B, and in D B take any point C, through which draw A E ; also, at D, at right angles to D B, draw D E, making the triangle D E C, and state,



As DC : DE :: BC : BA.

PROBLEM V.

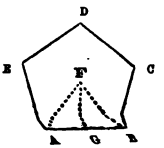
To find the area of any regular polygon.

Rule.—Multiply the sum of its sides by a perpendicular drawn from its centre to one of its sides, and take half the product for the area.

Or, Multiply the square of the side of a polygon (from three to twelve sides) by the numbers in the fourth column of the table for polygons, opposite the number of sides required, and the product will be the area nearly.

Example 1.—Required the area of the regular pentagon A B C D E, each side being 7.5, and perpendicular F G = 6.4.

$$\frac{7.5 \times 5 \times 6.4}{2} = 120 \text{ the area.}$$



EXAMPLE 2.—What is the area of a regular hexagon, each side being 8.75 in length?

$8.75^2 \times 2.598 = 199.009375$ the area.

Table of multipliers for polygons from three to twelve sides.

Names.	Sides.	Multipliers.	Multipliers.	Multipliers.	Areas.
Trigon	3	2	1.73	.579	.433
Tetragon	4	1.41	1.412	.705	1.000
Pentagon	5	1.238	1.174	.852	1.72
Hexagon	6	1.156	= Radius.	= Length of side.	2.598
Heptagon	7	1.11	.867	1.16	3.634
Octagon.....	8	1.08	.765	1.307	4.828
Nonagon	9	1.062	.681	1.47	6.1818
Decagon	10	1.05	.616	1.625	7.694
Undecagon ...	11	1.04	.561	1.777	9.365
Dodecagon ...	12	1.037	.515625	1.94	11.196

1.—*The breadth of a polygon given, to find the radius of a circle to contain that polygon.*

RULE.—Multiply half the breadth of the polygon by the numbers in the first column opposite to its name, or number of sides, and the product will be the radius of a circle to contain that polygon.

And if the polygon have an unequal number of sides, the half breadth is accounted from its centre to one of its sides.

2.—*The radius of a circle given, to find the length of side.*

RULE.—Multiply the radius of any circle by the numbers in the second column opposite the polygon required; and the product will be the length of side

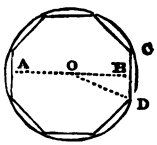
nearly that will divide that circle into the proposed number of sides. And,

3.—*The length of side given, to find the radius.*

RULE.—Multiply the given length of side by the numbers in the third column opposite the polygon required, and the product will be the radius of a circle to contain that polygon.

EXAMPLE 1.—Required the radius of a circle to contain an octagon, whose breadth A B = 18.5 inches.

Half of 18.5 = 9.25, and 9.25 × 1.08 = 9.99 or ten inches nearly, the radius of the circle O D.



EXAMPLE 2.—Given the radius O D = 9.99 inches; required the length of side D C.

9.99 × .765 = 7.64235, the length of side.

EXAMPLE 3.—Given the length of side D C = 7.64235; required the radius D O.

7.64235 × 1.307 = 9.98855145, or 9.99 in. nearly.

PROBLEM VI.

Having the diameter of a circle given, to find the circumference; or the circumference given, to find the diameter.

RULE 1.—As 7 is to 22, so is the diameter to the circumference.

Or, as 22 is to 7, so is the circumference to the diameter.

2.—As 1 is to 3.1416, so is the diameter to the circumference.

Or, as 3.1416 is to 1, so is the circumference to the diameter.

EXAMPLE 1.—Required the circumference of a circle when the diameter is 23.5.

$$\frac{23.5 \times 22}{7} = 73\tfrac{5}{7}, \text{ the circumference.}$$

EXAMPLE 2.—The circumference of a circle is $73\frac{5}{7}$, required the diameter.

$$\frac{73\frac{5}{7} \times 7}{22} = 23.5, \text{ the diameter.}$$

EXAMPLE 3.—Required the circumference of a circle whose diameter is 30.

$$3.1416 \times 30 = 94.248, \text{ the circumference.}$$

EXAMPLE 4.—What is the diameter of a circle when the circumference is 94.248?

$$94.248 \div 3.1416 = 30, \text{ the diameter.}$$

NOTE.—If the vessel is to be constructed with two ends, divide four times the required solidity by 3.1416, and the cube root of the quotient equal both length and diameter in equal terms.

Thus, $\frac{600 \times 4}{3.1416} = \sqrt[3]{764} = 9.142$ diameter and depth required.

PROBLEM VII.

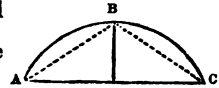
To find the length of any arc of a circle.

RULE.—Subtract the chord of the whole arc from eight times the chord of half the arc; and $\frac{1}{3}$ of the remainder is the length of the arc nearly.

EXAMPLE.—Required the length of the arc A B C; the chord of half the arc A B = 19.8, and chord of the whole arc A C = 34.4

$$19.8 \times 8 = 158.4 \text{ and}$$

$$\frac{158.4 - 34.4}{3} = 41.33, \text{ the length of the arc.}$$



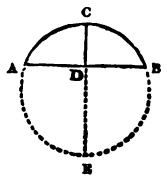
PROBLEM VIII.

To find the diameter of a circle, by having the chord and verse sine given.

RULE.—Divide the square of half the chord by the versed sine, to the quotient of which add the versed sine, and the sum will be the diameter.

Or, if the sum of the squares of the semichord and versed sine be divided by the versed sine, the quotient will be the diameter of the circle to which that segment corresponds.

EXAMPLE.—Given the chord A B = 24, and versed sine C D = 8; required the diameter of the circle C E.



Half the chord = 12 and $12^2 \div 8 = 18 + 8 = 26$, the diameter.

Or, $\frac{12^2 + 8^2}{8} = 26$, as before.

PROBLEM IX.

To find the area of an ellipsis, or oval.

RULE.—Multiply the longest diameter by the shortest, and the product by .7854, the result is the area.

An oval is 25 inches by 16.5, what are its superficial contents?

$25 \times 16.5 = 412.5 \times .7854 = 323.9775$ in., the area.

NOTE.—Multiply half the sum of the two diameters by 3.1416, and the product is the circumference of the oval or ellipsis.

PROBLEM X.

To find the area of a parabola, or its segment.

RULE.—Multiply the base by the perpendicular height, and two-thirds of the product is the area.

What is the area of a parabola whose base is 20 feet and height 12?

$$20 \times 12 = \frac{240 \times 2}{3} \text{ 160 feet, the area.}$$

Table of versed sines, whereby to ascertain the diameters of circles corresponding to any segment or part of a circle having a chord of three feet.

Length of chord three feet.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.
	Inches.	Ft. & In.	Inches.	Ft. & In.	Inches.	Ft. & In.
	6	5 0	2 3/4	10 0	1 1/2	18 0
	5 15/16	5 3	2 5/8 1/16	10 3	1 7/16 3/32	18 6
	5 1/2 & 3/32	5 6	2 9/16	10 6	1 3/8	19 0
	5 1/16	5 9	2 1/2 1/16	10 9	1 5/16 3/32	19 6
	4 31/32 3/32	6 0	2 7/16	11 0	1 1/4 3/32	20 0
	4 29/32 3/32	6 3	2 3/8 1/16	11 3	1 3/16 1/32	21 0
	4 27/32 1/32	6 6	2 5/16	11 6	1 1/8	22 0
	4 25/32 3/32	6 9	2 1/4 3/32	11 9	1 1/16 1/32	23 0
	4 3/4 1/32	7 0	2 3/16 1/32	12 0	1 1/32	24 0
	3 31/32 1/32	7 3	2 1/8 1/16	12 6	1 1/16	25 0
	3 15/16	7 6	2 1/32	13 0	1 1/32	26 0
	3 29/32 1/32	7 9	2 1/32	13 6	1 inch.	27 0
	3 7/8	8 0	1 15/16 1/16	14 0	31/32 1/32	28 0
	3 13/16	8 3	1 7/8	14 6	15/16 1/16	29 0
	3 3/4 1/32	8 6	1 13/16 1/16	15 0	29/32 1/32	30 0
	3 11/16 3/32	8 9	1 3/4	15 6	7/8 1/32	35 0
	3 5/8 1/16	9 0	1 11/16 1/16	16 0	13/16 1/32	40 0
	3	9 3	1 5/8	16 6	3/4 1/32	45 0
	2 31/32	9 6	1 9/16 1/32	17 0	11/16 1/16	50 0
	2 15/16 1/16	9 9	1 1/2 1/16	17 6		

Table of the relative proportions of the circle, its equal and inscribed squares.

1.	The Diameter of a circle	× .8862	=	the side of an equal square.
2.	„ Circumference.....	× 2821		
3.	„ Diameter	× .7071	=	the side of an inscribed square.
4.	„ Circumference	× .2251		
5.	„ Area	× .6366	=	the content of an inscribed square.
6.	„ Side of inscribed square	× 1.4142	=	the diameter of a circumscribing circle.
7.	„ Side of inscribed square	× 4.443	=	the circumference of a circumscribing circle.
8.	„ Side of a square	× 1.128	=	the diameter of an equal circle.
9.	„ Side of a square.....	× 3.545	=	the circumference of an equal circle.

Examples illustrative of the preceding table.

EXAMPLE 1.—The diameter of a circle is 12.5; required the side of a square equal in area to the given circle.

12.5 × .8862 = 11.07750, side of equal square.

Ex. 2.—The circumference of a circle being 53.4; required the side of a square equal in area.

53.4 × .2821 = 15.06414, side of equal square.

Ex. 3.—The diameter of a circle being 18; required the side of the greatest square that can be inscribed therein.

18 × .7071 = 12.7278, side of inscribed square.

Ex. 4.—The circumference of a circle is 86; required the side of inscribed square.

86 × .2251 = 19.3586, side of inscribed square.

Ex. 5.—The area of a circle being 371.5; required the area of the greatest square that can be inscribed within the circle.

371.5 × .6366 = 236.49690, area of the required square.

Ex. 6.—The side of a square being 19.375; required the diameter of its circumscribing circle.

19.375 × 1.4142 = 27.4001250, diameter.

Ex. 7.—Required the circumference of a circle to circumscribe a square, each side being 19.375.

19.375 × 4.443 = 86.083125, circumference of the circle required.

Ex. 8.—The side of a square being 13.5; required the diameter of a circle equal in area to the given square.

13.5 × 1.128 = 152.280, diameter of the circle required.

Ex. 9.—The side of a square being 13.5; required the circumference of a circle equal in area to the given square.

13.5 × 3.545 = 47.8575, circumference of the circle required.

Some of the properties of a circle.

1.—It is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2.—The areas of circles are to each other as the squares of their diameters, or of their radii.

3.—Any circle whose diameter is double that of another, contains four times the area of the other.

4.—The area of a circle is equal to the area of a triangle whose base is equal to the circumference, and perpendicular equal to the radius.

5.—The area of a circle is equal to the rectangle of its radius, and a right line equal to half its circumference.

6.—The area of a circle is found by squaring the diameter, and multiplying by the decimal .7854; or by multiplying the circumference by the radius, and dividing the product by two.

EXAMPLE 1.—Required the area of a circle, the diameter being 30.5.

$30.5^2 \times .7854 = 730.618350$, the area required.

EXAMPLE 2.—What is the area of a circle when the diameter is 1?

In this case the circumference is 3.1416, half of which is 1.5708, and half of 1 = .5; then 1.5708 × .5 = .7854, the area.

PROBLEM IX.

Having the area of a circle given, to find the diameter.

RULE.—As 355 is to 452, so is the area to the square of the diameter.

Or, multiply the square root of the area by 1.12837, and the product will be the diameter.

Or, divide the area by the decimal .7854, and extract the square root.

EXAMPLE.—Required the diameter of that circle whose area is 122.71875.

$$\frac{\sqrt{122.71875 \times 452}}{355} = 12.5 \text{ diameter.}$$

Or, $\sqrt{122.71875} = 11.077$; and $11.077 \times 1.12837 = 12.49895$, or 12.5 diameter.

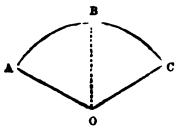
PROBLEM X.

To find the area of a sector of a circle.

RULE.—Multiply the length of the arc by the radius of the circle, and half the product will be the area.

EXAMPLE.—Required the area of a sector of a circle whose arc A B C = 26.666, and radius B O = 16.9.

$$\frac{26.666 \times 16.9}{2} = 225.3277$$



the area.

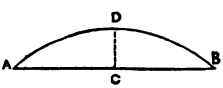
PROBLEM XI.

To find the area of a segment of a circle.

RULE.—Multiply the versed sine by the decimal .626, to the square of the product add the square of half the chord; multiply twice the square root of the sum by $\frac{2}{3}$ of the versed sine; and the product will be the area.

EXAMPLE.—Required the area of a segment of a circle whose chord A B = 48, and versed sine C D = 18.

$18 \times .626 = 11.268^2$ = 126.967824; which add to 576, being the square of half the chord = 702967824, twice the square root of which is 53.026 × 12; being $\frac{2}{3}$ of the versed sine = 636.312 the area.



The following is a near approximate to the preceding rule:

To the cube of the versed sine, divided by twice the length of the chord, add $\frac{2}{3}$ of the product of the chord, multiplied by the versed sine; and the sum will be the area of the segment nearly. Take the last example:—

Versed sine = 18, and chord 48, then, $\frac{18^3}{48 \times 2} = 60.7$

And $\frac{48 \times 18 \times 2}{3} = 576 + 60.7 = 636.7$, the area nearly.

Or, the area of a segment may be found by finding the area of a sector having the same radius as the segment; then deducting the area of the triangle leaves the area of the segment.

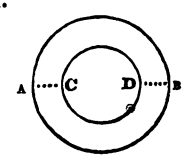
PROBLEM XII.

To find the area of a circular ring or space included between two concentric circles.

RULE.—Add the inside and outside diameters together, multiply the sum by their difference, and by .7854; and the product will be the area.

EXAMPLE.—The diameters of two concentric circles, A B and C D, are 10 and 6; required the area of the ring or space contained between them.

$\overline{10 + 6} \times 4 \times .7854 =$
50.2656 the area.



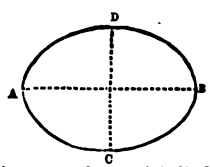
PROBLEM XIII.

To find the area of an ellipsis.

RULE.—Multiply the transverse or longer diameter by the conjugate or shorter diameter, and by .7854, and the product will be the area.

EXAMPLE.—Required the area of an ellipsis whose longer diameter A B = 12, and shorter diameter C D = 9.

$12 \times 9 \times .7854 =$
84.8232 the area.



NOTE.—If half the sum of the two diameters be multiplied by 3.1416, the product will be the circumference of the ellipsis, Thus, $12 + 9 = 21$, and $\frac{3.1416 \times 21}{2} = 36.1384$ the *circumference.*

MENSURATION OF SOLIDS.

By solids are meant all bodies, whether solid, fluid, or bounded space, that can be comprehended within length, breadth, and thickness.

PROBLEM I.

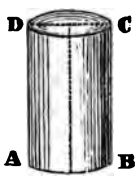
To find the convex surface and solid content of a cylindrical cylinder, or any figure of a cubical form.

RULE 1.—Multiply the circumference of the base by the height of the cylinder, and the product is the convex surface.

RULE 2.—Multiply the area of the base by the height of the cylinder, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of the cylinder A B C D, whose base A B = 32 inches, and perpendicular height B C = 6 feet.

3.1416 × 32 × 72 inches = 7238.2464 square or superficial inches, and 7238.2464 ÷ 144 = 50.2658 superficial feet.



EXAMPLE 2.—Required the solid content, in cubic inches and cubic feet, of the cylinder as above.

$32^2 \times .7854 \times 72 = 57905.9712$ cubic inches, and 57905.9712 ÷ 1728 = 33.5104 cubic feet.

EXAMPLE 3.—Suppose the cylinder A B C D be intended to contain a fluid, and that the sides and bottom are each one inch in thickness, how many imperial gallons would it contain ?

32 — 2 = 30 inches diameter; and 72 — 1 = 71 inches deep; then $\frac{30^2 \times .7854 \times 71}{277.274} =$ 181 gallons.

Or, 50187.06 × .003607 = 181, as before.

PROBLEM II.

To determine the dimensions of any cylindrical vessel, whereby to contain the greatest cubical contents, bounded by the least superficial surface.

RULE.—Multiply the given cubical contents by 2.56, and the cube root of the product equal the diameter, and half the diameter equal the depth.

EXAMPLE.—Suppose a cylindrical vessel is to be made so as to contain 600 cubic feet, and of such dimensions as to require the least possible materials by which it is constructed, what must be its depth and diameter?

600 × 2.56 = $\sqrt[3]{1536}$ = 11.5379 feet diameter, and 11.5379 ÷ 2 = 5.76895 feet in depth.

NOTE.—If the vessel is to be constructed with two ends, then the cube root of four times the solidity divided by 3.1416 equal both the length and diameter, so as to expose the least possible surface, or be composed of the least possible materials, of which to be constructed.

PROBLEM III.

To find the surface and solid content of a cone or pyramid.

RULE 1.—Multiply the circumference of the base by the slant height, and half the product will be the slant surface, to which add the area of the base, and the product will be the whole surface.

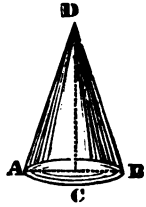
RULE 2.—Multiply the area of the base by the per-

pendicular height, and $\frac{1}{3}$ of the product will be the solid content.

EXAMPLE 1.—Required the convex surface of a cone whose base A B = 20 inches, and slant height B D = 29.5.

$$\frac{3.1416 \times 20 \times 29.5}{2} = 926.772$$

square inches, and divided by 144 = 6.435 superficial feet.



EXAMPLE 2.—Required the solidity of the cone as above, the perpendicular C D being 28 inches.

$$\frac{20^2 \times .7854 \times 28}{3} = 2932.16$$ cubic inches, and divided by 1728 = 1.697 cubic feet.

PROBLEM IV.

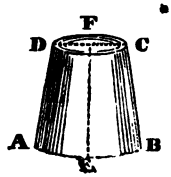
To find the surface of the frustum of a cone or pyramid.

RULE.—Multiply the sum of the perimeters of the two ends by the slant height, and half the product will be the slant surface; to which add the areas of the two ends, and the product will be the whole surface.

EXAMPLE.—Required the convex surface of the frustum of a cone A B C D, whose base A B = 20 inches, the slant height B C = 19, and top end C D = 11

$$\frac{3.1416 \times 20 + 3.1416 \times 11 \times 19}{2}$$

= 925.2012 square inches, and divided by 144 = 6.425 feet nearly.



PROBLEM V.

To find the solid content of the frustum of a cone.

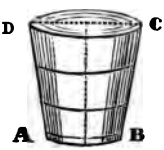
RULE.—To the product of the diameters of the two ends, add the sum of their squares; multiply this sum by the perpendicular height and by .2618, the product is the solid content.

EXAMPLE 1.—Required the solid content of the frustum in Problem IV, whose perpendicular E F = 18 inches.

$20 \times 11 = 220$, and $220 + 20^2 + 11^2 \times 18 \times .2618 = 3491.8884$ cubic inches, and divided by $1728 = 2.0208$ cubic feet nearly.

EXAMPLE 2.—Required the content, in imperial gallons, of the inverted frustum of a cone A B C D, whose inner dimensions are $3\frac{1}{2}$ feet deep, 18 inches diameter at bottom, and 22 inches diameter at top.

$22 \times 18 = 396$ and $\overline{396 + 22^2 + 18^2} \times 42 \times .2618 = \frac{13238.7024}{277.274} =$ 47.745 gallons nearly.



Or, $13238.7024 \times 0.00360654 = 47.75$ gallons nearly, as before.

PROBLEM VI.

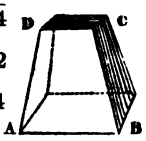
To find the solid content of the frustum of a pyramid.

RULE.—To the sum of the areas of the two ends add the square root of their product; multiply this sum by the perpendicular height, and $\frac{1}{3}$ of the product is the solid content.

EXAMPLE. — Required the solid content of the frustum of a pyramid A B C D, whose perpendicular

height = 24 inches, the area of the base = 144 inches, and area of the top end = 64.

$144 + 64 = 208$ and $\sqrt{144 \times 64} = 96$, then $\frac{208 + 96 \times 24}{3} = 2432$ cubic inches, and $\div 1728 = 1.4074$ cubic feet nearly.



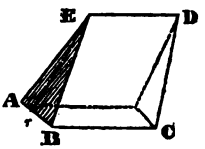
PROBLEM VII.

To find the solidity of a wedge.

RULE.—To the length of the wedge add twice the length of the base; multiply that sum by the height, and by the breadth of the base, and one sixth of the product will be the solidity.

EXAMPLE.—Required the content in cubic inches of the wedge A B C D E, whose base A B C = 12 inches long and 4 inches broad, the length of the edge D E = 10 inches, and perpendicular height *r* E = 20 inches.

$\frac{\overline{10 + 24} \times 20 \times 4}{6} = 453.33$ cubic inches.



PROBLEM VIII.

To find the convex surface and solid content of a sphere or globe.

RULE 1.—Multiply the square of the diameter by 3.1416, the product will be the convex superficies.

RULE 2.—Multiply the cube of the diameter by .5236, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

$25.5^2 \times 3.1416 = 2042.8254$ square inches, $\div 144 = 14.1862$ square or superficial feet.

EXAMPLE 2.—Required the solid content of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

$25.5^3 \times .5236 = 8682.00795$ cubic inches, $\div 1728 = 5.0243$ cubic feet.

PROBLEM IX.

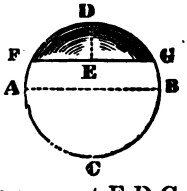
To find the convex surface and solid content of the segment of a sphere.

RULE 1.—Multiply the height of the segment by the whole circumference of the sphere, and the product is the curved surface.

RULE 2.—Add the square of the height to three times the square of the radius of the base; multiply that sum by the height, and by .5236, and the product is the solid content.

EXAMPLE 1.—The diameter A B of the sphere A B C D = 20 inches; what is the convex surface of that segment of it whose height E D = 8 inches?

$3.1416 \times 20 \times 8 = 502.656$ square inches $\div 144 = 3.49$ superficial feet.



EXAMPLE 2.—The base F G of the segment F D G

= 18 inches, and perpendicular E D = 8, what is the solid content?

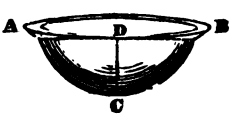
$8^2 = 64$, and $9^2 \times 3 = 243$, then $243 + 64 \times 8 \times .5236 = 1285.9616$ cubic inches $\div 1728 = .7441$ cubic feet.

EXAMPLE 3.—Suppose A B C D to be a sugar pan, and that the diameter of the mouth A B is 4 feet, the depth D C being 25 inches, how many imperial gallons will it contain?

$25^2 = 625$, and $24^2 \times 3 = 1728$, then $1728 + 625 \times 25 \times .5236 = 30.800.77$

277.274

= 111.084 gallons.



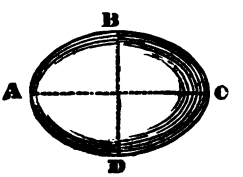
PROBLEM X.

To find the solidity of a spheroid.

RULE.—Multiply the square of the revolving axis by the fixed axis, and by .5236, and the product will be the solidity.

EXAMPLE 1.—Required the solid content of the prolate spheroid A B C D, whose fixed axis A C is 50, and revolving axis B D 30.

$30^2 \times 50 \times .5236 =$ 23562, the solidity.



EXAMPLE 2.—What is the solid content of an oblate spheroid, the fixed axis being 30, and revolving axis 50?

$50^2 \times 30 \times .5236 = 39270$, the solid content.

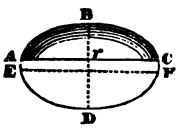
PROBLEM XI.

To find the solidity of the segment of a spheroid when the base is circular or parallel to the revolving axis.

RULE.—From triple the fixed axis take double the height of the segment; multiply the difference by the square of the height, and by .5236; then say, as the square of the fixed axis is to the square of the revolving axis, so is the former product to the solidity.

EXAMPLE 1.—Required the solid content of the segment A B C, whose height B r is 10; the revolving axis E F being 40, and fixed axis B D 25.

$\overline{25 \times 3} - \overline{10 \times 2} = 55$
and $55 \times 10^2 \times .5236 = 2879.8$; then as $25^2 : 40^2 :: 2879.8 : 7372.3$ nearly.



EXAMPLE 2.—What is the solid content of the segment of a spheroid whose height = 20 inches, the revolving axis being 25, and fixed axis 50?

$\overline{50 \times 3} - \overline{20 \times 2} = 110$, and $110 \times 20^2 \times .5236 = 23038.4$; then, as $50^2 : 25^2 :: 23038.4 : 5759.6$ inches, the solid content.

PROBLEM XII.

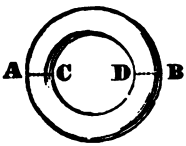
To find the convex surface and solid content of a cylindric ring.

RULE 1.—Multiply the thickness of the ring added to the inner diameter, by the thickness and by 9.8698, and the product will be the convex surface.

RULE 2.—To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness and by 2.4674, and the product will be the solid content.

EXAMPLE 1.—The thickness of a cylindric ring A C or D B = 2 inches, and inner diameter = 18, required the convex superficies.

$\overline{18 + 2} \times 2 \times 9.8698 =$ 394.792 square inches, and $\div$ 144 = 2.741 superficial feet nearly.



EXAMPLE 2.—Required the solid content of the ring as above.

$18 + 2 \times 2^2 \times 2.4674 = 197.392$ cubic inches and $\div$ 1728 = .114 cubic feet.

NOTE.—A cubic foot is equal to 1728 cubic inches;
or 2200 cylindrical inches;
or 3300 spherical inches;
or 6600 conical inches.

Also, the cubic foot being considered unity, or 1,
A cylinder 1 foot diameter, and 1 foot in length = .7854
A sphere 1 foot in diameter ..... = .5236
And a cone 1 foot diameter at the base and 1 foot in height..... = .2619

OF TIMBER MEASURE.

Timber is chiefly estimated by the square or superficial foot of 144 inches, or cubic foot of 1728; the calculation of which is performed by duodecimals; that is, the foot or inch, &c., divided into 12 parts or divisions, thus:—

12 fourths make .....1 third,
12 thirds ,, ...1 second,
12 seconds ,, ...1 inch,
12 inches ,, ...1 foot.

And the several values arising are:—

Feet multiplied by feet give feet,
Feet multiplied by inches give inches,
Feet multiplied by seconds give seconds,
Inches multiplied by inches give seconds,
Inches multiplied by seconds give thirds,
Seconds multiplied by seconds give fourths, &c.

But this rule is more commonly called Cross Multiplication, on account of commencing with the left hand figure of the multiplier.

Rule 1.—Place the multiplier under the multiplicand, feet under feet, inches under inches, seconds under seconds, &c.

2.—Multiply each denomination of the length by the feet of the breadth, beginning at the lowest, and place each product under that denomination of the multiplicand from which it arises, always carrying one for every 12.

3.—Multiply by the inches, and set each product one place farther to the right hand.

4.—Then multiply by the seconds, and set each product another place toward the right hand, &c.

Thus proceed in like manner with all the other denominations, and their sum will be the content.

EXAMPLE 1.—Required the superficial content of a board 12 feet 6 inches long and 1 foot $5\frac{1}{2}$ inches broad.

	F.	I.	
	12	6	
Multiplied by	1	5	6
	12	6	
	5	2	6
		6	3
Feet	18	2	9

When the two ends of a board or plank are of different breadths, add the two breadths together, and multiply the length by half the sum.

EXAMPLE 2.—A plank that is 1 foot 4 inches broad at one end, $11\frac{1}{2}$ inches broad at the other, and 18 feet 9 inches long, what is its superficial content?

$16 + 11\frac{1}{2} = 27\frac{1}{2} \div 2 = 13\frac{3}{4}$ inches.

	F.	I.		
Then	18	9		
$13\frac{3}{4}$ inches =	1	1	9	
	18	9		
	1	6	9	
	1	2	0	9
Feet	21	5	9	9

Superficial measure by the Engineer's Slide Rule.

When the length is given in feet, and the breadth in inches, the gauge point is 12; but if the dimensions are all inches, the gauge point is 144.

RULE.—Set the breadth upon B to the gauge point upon A, and against the length upon A is the content in square feet upon B.

EXAMPLE 1.—Required the number of square feet contained in a board $11\frac{1}{2}$ inches broad and 18 feet long.

Set 11.5 upon B to 12 upon A; and against 18 upon A is 17.3 feet upon B.

The content of one board being found, the content of any number of the same dimensions may be found by setting 1 upon B to the content of the one found upon A; and against any number of boards upon B is the whole content upon A.

Find the content of 8 boards, each being 17.3 square feet.

Set 1 upon B to 17.3 upon A; and against 8 upon B is 138.4 feet upon A.

EXAMPLE 2.—If a board is 10 inches broad at one end, and 7 at the other, what must be its length to make a square foot?

$10 + 7 = 17 \div 2 = 8\frac{1}{2}$ inches. Set 8.5 upon B to 144 upon A; and against 1 upon B is 16.9 inches long upon A.

To find the solidity of timber.

The solid content of timber (according to custom) is found by multiplying the length by the square of the $\frac{1}{4}$ girth.

EXAMPLE.—Required the content of a tree in cubic feet, whose girth in the middle is 84 inches, and length 25 feet 6 inches.

$84 \div 4 = 21$ inches $\frac{1}{4}$ girth.

	F.	I.		
and 21 inches =	1	9		
Multiplied by	1	9		
	1	9		
	1	3	9	
=	3	0	9	

	F.	I.		
Then	25	6		
Multiplied by	3	0	9	
	76	6		
	1	7	1	6
Feet	78	1	1	6

But a more expeditious method is obtained by means of the following

TABLE.

¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.
6	.250	12¼	1.042	19	2.506
6¼	.272	12½	1.085	19½	2.640
6½	.294	12¾	1.129	20	2.777
6¾	.317	13	1.174	20¼	2 917
7	.340	13¼	1.219	21	3 062
7¼	.364	13½	1.265	21½	3.209
7½	.390	13¾	1.313	22	3.362
7¾	.417	14	1.361	22½	3.516
8	.444	14¼	1.410	23	3.673
8¼	.472	14½	1.460	23½	3.835
8½	.501	14¾	1 511	24	4.000
8¾	.531	15	1.562	24½	4.168
9	.562	15¼	1.615	25	4.340
9¼	.594	15½	1.668	25½	4.516
9½	.626	15¾	1.722	26	4.694
9¾	.659	16	1.777	26½	4.876
10	.694	16¼	1.833	27	5.062
10¼	.730	16½	1.890	27½	5.252
10½	.766	16¾	1.948	28	5.444
10¾	.803	17	2.006	28½	5.640
11	.840	17¼	2.066	29	5.840
11¼	.878	17½	2.126	29½	6.044
11½	.918	17¾	2.187	30	6.250
11¾	.959	18	2.250		
12	1.000	18½	2.376		

RULE.—Multiply the area corresponding to the ¼ girth in inches by the length of the timber in feet; and the product is the solidity in feet and decimal parts.

EXAMPLE.—A piece of timber, 18 feet long and 14 inches square, how many cubic feet does it contain?

1.361 × 18 = 24.498 cubic feet.

By the Slide Rule.

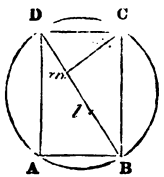
Set the length in feet upon B to 144 upon A; and against the square, or $\frac{1}{4}$ girth upon D, is the solid content in feet upon C.

EXAMPLE.—How many cubic feet is contained in a tree 28 feet long and 16 inches $\frac{1}{4}$ girth?

Set 28 upon B to 144 upon A; and against 16 upon D is 49.9 feet upon C.

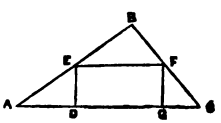
To find the transverse section of the strongest beam that can possibly be cut out of a round piece of timber.

Let A B C D be the piece of timber given, draw the diameter B D, and divide it into three equal parts, as B *l* *m* D, erect the perpendicular *m* C, meeting the circle in C, draw D C and C B; then draw A B equal and parallel to D C, likewise A D equal and parallel to B C, and the rectangle will be a section of the beam as required.



To determine the greatest rectangle that can possibly be obtained in a given triangle.

Let A B C be a given triangle, bisect any two of its sides, as E F; join E F, and to each end of which draw lines at right angles with the other side A C, and D E F G will be the rectangle required.



ON THE STRENGTH OF MATERIALS.

A knowledge of the strength of materials is one of the most important, and at the same time one of the most difficult subjects that the practical mechanic has to contend with, owing chiefly to the very different qualities of bodies of the same name; hence arise some doubts in selecting experiments whereon to build a data, there being scarcely two experiments made producing the same results. However, the following tables and rules are founded upon a mean of Messrs. Rennie, Barlow, and Telford's experiments, having found them to agree the best with practice, and my own experiments on similar bodies.

ON THE COHESIVE STRENGTH OF BODIES.

The cohesive strength of a body is that force with which it resists separation in the direction of its length, as in the case of ropes, &c.; and no reason can be assigned why the strength should not vary directly as the section of fracture, and is totally independent of the length in position, except so far as the weight of the body may increase the force applied: neglecting this, and supposing the body uniform in all its parts, the strength of bodies exposed to strains in the direction of their length is directly proportionate to their transverse area, whatever be their figure, length, or position.

The following Table contains the result of experiments on the cohesive strength of various bodies in avoirdupois pounds;— also one-third of the ultimate strength of each body, this being considered sufficient, in most cases, for a permanent load.

Names of Bodies.	Sq. Bar.	1 third.	Rnd. Bar.	1 third.
WOODS.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Boxwood	20000	6667	15708	5236
Ash	17000	5667	13357	4452
Teak	15000	5000	11781	3927
Fir	12000	4000	9424	3141
Beech	11500	3866	9032	3011
Oak	11000	3667	8639	2880
METALS.				
Cast iron	18656	6219	14652	4884
English wrt. iron	55872	18624	43881	14627
Swedish do do.	72064	24021	56599	18866
Blistered steel	133152	44384	104577	34859
Shear do.	124400	41366	97703	32568
Cast do.	134256	44752	105454	35151
Cast copper	19072	6357	14979	4993
Wrought do.	33792	11264	26540	8847
Yellow brass	17968	5989	14112	4704
Cast tin	4736	1579	3719	1239
Cast lead	1824	608	1432	477

PROBLEM I.

To find the ultimate cohesive strength of square, round, and rectangular bars, of any of the various bodies, as specified in the table.

RULE.—Multiply the strength of an inch bar, (as in the table,) of the body required, by the cross sectional area of square and rectangular bars, or by the square of the diameter of round bars; and the product will be the ultimate cohesive strength.

EXAMPLE 1.—A bar of cast iron being $1\frac{1}{2}$ inches square, required its cohesive power.

$$1.5 \times 1.5 \times 18656 = 41976 \text{ lbs.}$$

EXAMPLE 2.—Required the cohesive force of a bar of English wrought iron, 2 inches broad, and $\frac{3}{8}$ of an inch in thickness.

$$2 \times .375 \times 55872 = 41904 \text{ lbs.}$$

EXAMPLE 3.—Required the ultimate cohesive strength of a round bar of wrought copper, $\frac{3}{4}$ of an inch in diameter.

$$.75^2 \times 26540 = 14928.75 \text{ lbs.}$$

PROBLEM II.

The weight of a body being given, to find the cross sectional dimensions of a bar or rod capable of sustaining that weight.

RULE.—For square and round bars,—Divide the weight given by one-third of the cohesive strength of an inch bar, (as specified in the table,) and the square root of the quotient will be the side of the square, or diameter of the bar in inches.

And if rectangular, divide the quotient by the breadth, and the result will be the thickness.

EXAMPLE 1.—What must be the side of a square bar of Swedish iron to sustain a permanent weight of 18000 lbs?

$$\sqrt{\frac{18000}{24021}} = .86, \text{ or nearly } \tfrac{7}{8} \text{ of an inch square.}$$

EXAMPLE 2.—Required the diameter of a round rod of cast copper to carry a weight of 6800 lbs.

$$\sqrt{\frac{6800}{4993}} = 1.16 \text{ inches diameter.}$$

EXAMPLE 3.—A bar of English wrought iron is to be applied to carry a weight of 2760 lbs; required the thickness, the breadth being two inches.

$$\frac{2760}{18624} = .142 \div 2 = .071 \text{ of an inch in thickness.}$$

A TABLE

Showing the circumference of a rope equal to a chain made of iron of a given diameter, and the weight in tons that each is proved to carry; also the weight of a foot of chain made from iron of that dimension.

Ropes. Cir. in Ins.	Chains. Dia. in Ins.	Proved to carry in tons.	Weight of a lineal foot in lbs. Avr.
3	$\frac{1}{4}$ & $\frac{1}{16}$	1	1.08
4	$\frac{3}{8}$	2	1.5
$4\frac{3}{4}$	$\frac{3}{8}$ & $\frac{1}{16}$	3	2
$5\frac{1}{4}$	$\frac{1}{2}$	4	2.7
6	$\frac{1}{2}$ & $\frac{1}{16}$	5	3.3
$6\frac{1}{2}$	$\frac{5}{8}$	6	4
7	$\frac{5}{8}$ & $\frac{1}{16}$	8	4.6
$7\frac{1}{2}$	$\frac{3}{4}$	$9\frac{3}{4}$	5.5
8	$\frac{3}{4}$ & $\frac{1}{16}$	$11\frac{1}{4}$	6.1
9	$\frac{7}{8}$	13	7.2
$9\frac{1}{2}$	$\frac{7}{8}$ & $\frac{1}{16}$	15	8.4
$10\frac{1}{2}$	1 inch.	18	9.4

ON THE TRANSVERSE STRENGTH OF BODIES.

The *transverse strength* of a body is that power which it exerts in opposing any force acting in a perpendicular direction to its length, as in the case of beams, levers, &c., for the fundamental principles of which observe the following:—

That the transverse strength of beams, &c., is inversely as their lengths, and directly as their breadths, and square of their depths, and, if cylindrical, as the cubes of their diameters; that is, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can carry 2000 lbs., another beam of the same material, 12 feet long, 2 inches broad, and 4 inches deep, will only carry 1000, being inversely as their lengths. Again, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can sup-

port a weight of 2000 lbs., another beam of the same material, 6 feet long, 4 inches broad, and 4 inches deep, will support double that weight, being directly as their breadths;—but a beam of that material, 6 feet long, 2 inches broad, and 8 inches deep, will sustain a weight of 8000 lbs.; being as the square of their depths.

From a mean of experiments made, to ascertain the transverse strength of various bodies, it appears that the ultimate strength of an inch square, and an inch round bar of each, 1 foot long, loaded in the middle, and lying loose at both ends, is nearly as follows, in lbs. avoirdupois.

Names of Bodies.	Sq. Bar.	One-third.	Rnd. Bar.	One-third.
Oak	800	267	628	209
Ash	1137	379	893	298
Elm	569	189	447	149
Pitch pine	916	305	719	239
Deal	566	188	444	148
Cast iron	2580	860	2026	675
Wrought iron	4013	1338	3152	1050

PROBLEM I.

To find the ultimate transverse strength of any rectangular beam, supported at both ends, and loaded in the middle; or supported in the middle, and loaded at both ends; also, when the weight is between the middle and the end; likewise, when fixed at one end and loaded at the other.

RULE.—Multiply the strength of an inch square bar, 1 foot long, (as in the table,) by the breadth, and square of the depth in inches, and divide the product by the length in feet; the quotient will be the weight in lbs. avoirdupois.

EXAMPLE 1.—What weight will break a beam of oak 4 inches broad, 8 inches deep, and 20 feet between the supports?

$$\frac{800 \times 4 \times 8^2}{20} = 10240 \text{ lbs.}$$

NOTE.—When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle; that is, each end will bear half the weight.

When the weight is not situated in the middle of the beam, but placed somewhere between the middle and the end,—Multiply twice the length of the long end by twice the length of the short end, and divide the product by the whole length of the beam: the quotient will be the effectual length.

EXAMPLE 2.—Required the ultimate transverse strength of a pitch pine plank, 24 feet long, 3 inches broad, 7 inches deep, and the weight placed 8 feet from one end.

$$\frac{32 \times 16}{24} = 21.3 \text{ effective length.}$$

and

$$\frac{916 \times 3 \times 7^2}{21.3} = 6321 \text{ lbs.}$$

Again, when a beam is fixed at one end and loaded at the other, it will only bear $\frac{1}{4}$ of the weight as when supported at both ends and loaded in the middle.

EXAMPLE 3.—What is the weight requisite to break a deal beam 6 inches broad, 9 inches deep, and projecting 12 feet from the wall?

$$\frac{566 \times 6 \times 9^2}{12} = 22923 \div 4 = 5730.7 \text{ lbs.}$$

The same rules apply as well to beams of a cylindrical form, with this exception, that the strength of a round bar (as in the table) is multipled by the cube of the diameter, in place of the breadth, and square of the depth.

EXAMPLE 4.—Required the ultimate transverse strength of a solid cylinder of cast iron, 12 feet long and 5 inches diameter.

$$\frac{2026 \times 5^3}{12} = 21104 \text{ lbs.}$$

EXAMPLE 5.—What is the ultimate transverse strength of a hollow shaft of cast iron, 12 feet long, 8 inches diameter outside, and containing the same cross sectional area as a solid cylinder 5 inches diameter?

$$\sqrt{8^2 - 5^2} = 6.24, \text{ and } 8^3 - 6.24^3 = 269.$$

Then, $$\frac{2026 \times 269}{12} = 45416 \text{ lbs.}$$

NOTE.—When a beam is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when loose at both ends.

And if a beam is loose at both ends, and the weight laid uniformly along its length, it will bear double; but if fixed at both ends, and the weight laid uniformly along its length, it will bear triple the weight.

PROBLEM II.

To find the breadth or depth of beams intended to support a permanent weight.

RULE.—Multiply the length between the supports, in feet, by the weight to be supported in lbs., and divide the product by one-third of the ultimate strength of an inch bar, *(as in the table,)* multiplied by the square of the depth; the quotient will be the breadth, or, multiplied by the breadth, the quotient will be the square of the depth, both in inches.

EXAMPLE 1.—Required the breadth of a cast iron beam, 16 feet long, 7 inches deep, and to support a weight of 4 tons in the middle.

4 tons = 8960 lbs. and

$$\frac{8960 \times 16}{860 \times 7^2} = 3.4 \text{ inches.}$$

EXAMPLE 2.—What must be the depth of a cast iron beam 3.4 inches broad, 16 feet long, and to bear a permanent weight of four tons in the middle?

$$\sqrt{\frac{8960 \times 16}{860 \times 3.4}} = 7 \text{ inches.}$$

NOTE 1.—When a beam is fixed at both ends, the divisor must be multiplied by 1.5, on account of it being capable of bearing one-half more.

2.—When a beam is loaded uniformly throughout, and loose at both ends, the divisor must be multiplied by 2, because it will bear double the weight.

3.—If a beam is fast at both ends, and loaded uniformly throughout, the divisor must be multiplied by 3, on account that it will bear triple the weight.

EXAMPLE 3.—Required the breadth of an oak beam, 20 feet long, 12 inches deep, made fast at both ends, and to be capable of supporting a weight of 12 tons in the middle.

12 tons = 26880 lbs. and

$$\frac{26880 \times 20}{266 \times 12^2 \times 1.5} = 9.7 \text{ inches.}$$

Again, when a beam is fixed at one end, and loaded at the other, the divisor must be multiplied by .25; because it will only bear one-fourth of the weight,

EXAMPLE 4.—Required the depth of a beam of ash, 6 inches broad, 9 feet projecting from the wall, and to carry a weight of 47 cwt.

47 cwt. = 5264 lbs. and

$$\sqrt{\frac{5264 \times 9}{379 \times 6 \times .25}} = 9.12 \text{ inches deep.}$$

And when the weight is not placed in the middle of a beam, the effective length must be found as in Problem I.

EXAMPLE 5.—Required the depth of a deal beam

20 feet long, and to support a weight of 63 cwt. 6 feet from one end.

$$\frac{28 \times 12}{20} = 16.8 \text{ effective length of beam, and}$$

$$63 \text{ cwt.} = 7056 \text{ lbs. hence}$$

$$\sqrt{\frac{7056 \times 16.8}{188 \times 6}} = 10.24 \text{ inches deep.}$$

Beams or shafts exposed to lateral pressure are subject to all the foregoing rules, but in the case of water-wheel shafts, &c., some allowances must be made for wear, then the divisor may be changed from 675 to 600 for cast iron.

EXAMPLE 6.—Required the diameter of bearings for a water-wheel shaft 12 feet long, to carry a weight of 10 tons in the middle.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400}{600} = \sqrt[3]{448} = 7.65 \text{ inches diameter.}$$

And when the weight is equally distributed along its length, the cube root of half the quotient will be the diameter, thus:

$$\frac{448}{2} = \sqrt[3]{224} = 6.07 \text{ inches diameter.}$$

EXAMPLE 7.—Required the diameter of a solid cylinder of cast iron, for the shaft of a crane, to be capable of sustaining a weight of 10 tons; one end of the shaft to be made fast in the ground, the other to project $6\frac{1}{2}$ feet; and the effective leverage of the jib as $1\frac{3}{4}$ to 1.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400 \times 6.5 \times 1.75}{675 \times .25} = 1509$$

And $\sqrt[3]{1509} = 11.47$ inches diameter.

The strength of cast iron to wrought iron, in this direction, is as 9 is to 14 nearly; hence, if wrought iron is taken in place of cast iron in the last example, what must be its diameter?

$$\sqrt[3]{\frac{1509 \times 9}{14}} = 9.89 \text{ inches diameter.}$$

ON TORSION OR TWISTING.

The strength of bodies to resist *torsion*, or wrenching asunder, is directly as the cubes of their diameters; or, if square, as the cube of one side; and inversely as the force applied multiplied into the length of the lever.

Hence the rule.—1. Multiply the strength of an inch bar, by experiment, *(as in the following table,)* by the cube of the diameter, or of one side in inches; and divide by the radius of the wheel, or length of the lever also in inches; and the quotient will be the ultimate strength of the shaft or bar, in lbs. avourdupois.

2.—Multiply the force applied in pounds by the length of the lever in inches, and divide the product by one-third of the ultimate strength of an inch bar, *(as in the table,)* and the cube root of the quotient will be the diameter, or side of a square bar in inches; that is, capable of resisting that force permanently.

The following Table contains the result of experiments on inch bars, of various metals, in lbs. avoirdupois.

Names of Bodies.	Rd. Bar.	1 third.	Sq. Bar.	1 third.
Cast iron	11943	3981	15206	5069
English wrt. iron.	12063	4021	15360	5120
Swedish do. do....	11400	3800	14592	4864
Blistered steel ...	20025	6675	25497	8499
Shear do.	20508	6836	26112	8704
Cast do.	21111	7037	26880	8960
Yellow brass.....	5549	1850	7065	2355
Cast copper	4825	1608	6144	2048
Tin	1688	563	2150	717
Lead	1206	402	1536	512

EXAMPLE 1.—What weight, applied on the end of a 5 feet lever, will wrench asunder a 3 inch round bar of cast iron?

$$\frac{11943 \times 3^3}{60} = 5374 \text{ lbs. avoirdupois.}$$

EXAMPLE 2.—Required the side of a square bar of wrought iron, capable of resisting the twist of 600 lbs. on the end of a lever 8 feet long.

$$\sqrt[3]{\frac{600 \times 96}{5120}} = 2\tfrac{1}{4} \text{ inches.}$$

In the case of revolving shafts for machinery, &c., the strength is directly as the cubes of their diameters, and revolutions, and inversely as the resistance they have to overcome; hence,

From *practice*, we find that a 40-horse power steam-engine, making 25 revolutions per minute, requires a shaft *(if made of wrought iron)* to be 8 inches diameter: now, the cube of 8, multiplied by 25, and divided by 40 = 320; which serves as a constant multiplier for all others in the same proportion.

EXAMPLE 3.—What must be the diameter of a wrought iron shaft for an engine of 65-horse power, making 23 revolutions per minute?

$$\sqrt[3]{\frac{65 \times 320}{23}} = 9.67 \text{ inches diameter.}$$

Mr. Robertson Buchanan, in his Essay on Shafts, gives 400 as a constant multipler for cast iron shafts that are intended for first movers in machinery;

200 for second movers; and

100 for shafts connecting smaller machinery, &c.

EXAMPLE 1.—The velocity of a 30-horse power steam-engine is intended to be 19 revolutions per

minute. Required the diameter of bearings for the fly wheel shaft.

$$\sqrt[3]{\frac{400 \times 30}{19}} = 8.579 \text{ inches diameter.}$$

EXAMPLE 2.—Required the diameter of the bearings of shafts, as second movers from a 30-horse engine; their velocity being 36 revolutions per minute.

$$\sqrt[3]{\frac{200 \times 30}{36}} = 5.5 \text{ inches diameter.}$$

NOTE.—When shafting is intended to be of wrought iron, use 160 as the multiplier for second movers; and 80 for shafts connecting smaller machinery.

TABLE

Of the proportionate length of bearings, or journals for shafts of various diameters.

Dia. in Inches.	Len. in Inches.	Dia. in Inches.	Len. in Inches.
1	1¾	6½	8¾
1½	2¼	7	9⅜
2	3	7½	10
2½	3¼	8	10¾
2⅝	3½	8½	11⅜
3	4¼	9	12
3½	4⅞	9½	12¾
4	5½	10	13¼
4½	6⅛	10½	14
5	6¾	11	14⅝
5½	7⅜	11½	15¼
6	8¼	12	16

OF THE MECHANICAL POWERS.

When power is applied to overcome weight, or force to overcome resistance, the machines employed are called mechanic powers; and the application of such, the science of mechanics.

The power and weight are said to balance each other, or to be in equilibrio, when the effort of the one to produce motion in one direction is equal to the effort of the other to produce it in an opposite direction; or when the weight opposes that degree of resistance which is precisely required to destroy the action of the power.

The momentum or quantity of force of any moving body is the result of the quantity of matter multiplied by the velocity by which it is moved; and when the product arising from the multiplication of the particular quantities of matter in any two bodies by their respective velocities are equal, their momentum will be so too.

And it holds universally true, that when two bodies are suspended upon any machine, so as to act contrary to each other, if the machine be put in motion, and the perpendicular ascent of one body, multiplied into its weight, be equal to the perpendicular descent of the other multiplied into its weight, those bodies, however unequal they may be in weight, will balance each other in all situations; for, as the whole ascent of the one is performed in the same time as the whole descent of the other, their respective velocities must be as the spaces they move through; and the excess of weight in the one is compensated by the excess of velocity in the other. Upon this principle it is easy to compute the power of any machine; either simple or compound; for it is only finding how much swifter the power moves than the weight; and just so much is the power increased by the help of the machine.

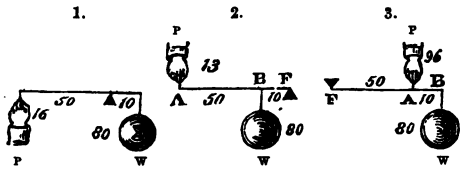
The simple machines, usually called mechanic powers, are six in number, namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw.

There are three kinds of levers, caused by the different situations of the weights, props, and powers.

1.—When the weight is at one end, the power at the other, and the prop somewhere between.

2.—When the prop is at one end, the power at the other, and the weight between. And,

3.—When the prop is at one end, the weight at the other, and the power between. Thus,



In the first and second kind, the advantage gained is as the distance of the power from the prop, to the distance of the weight from the prop.

In the third kind, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight, just as much as the distance of the weight from the prop exceeds the distance of the power from the prop, that is, P × A F = W × B F; or the power and weight are reciprocally as the distances at which they act.

Or, in other words, multiply the weight given by the distance from the prop, and divide by the distance from the power; the quotient will be the power or weight required.

EXAMPLES 1, 2, and 3

Required the power necessary to counterpois a weight of 80 lbs. on each of the three levers, whose lengths

are 60 inches, and in the first and second 10 inches from weight to prop, the third being 10 inches from weight to power.

$$\text{First....}\frac{80 \times 10}{50} = 16 \text{ lbs. power.}$$

$$\text{Second..}\frac{80 \times 10}{60} = 13.33 \text{ lbs. power.}$$

$$\text{Third...}\frac{80 \times 60}{50} = 96 \text{ lbs. power.}$$

EXAMPLE 4.—What power is necessary to raise a weight of 620 lbs. by a lever of the first order, 72 inches long, and the prop placed 12 inches from the weight?

$$72 - 12 = 60 \text{ inches to power.}$$

$$\text{Then } \frac{620 \times 12}{60} = 124 \text{ lbs.}$$

EXAMPLE 5.—A weight of 620 lbs. is to be lifted by a power of 124 lbs. applied to the end of a lever of the first order, 72 inches long; required at what distance from the weight the prop must be placed.

$$\frac{124 \times 72}{620 + 124} = 12 \text{ inches.}$$

EXAMPLE 6.—A beam 20 feet long, and supported at both ends, bears a weight of 73 cwt. 4 feet 6 inches from one end; required the proportion of weight upon each support.

$$\frac{73 \times 4.5}{20} = 16.425 \text{ cwt. on the furthest support.}$$

$$\text{And } \frac{73 \times 15.5}{20} = 56.675 \text{ cwt. on the nearest support.}$$

EXAMPLE 7.—A weight of 300 lbs. is fixed on the end of a lever 6 feet long; required the power, applied $2\frac{1}{2}$ feet from the prop, to raise the weight.

$$\frac{300 \times 6}{2.5} = 720 \text{ lbs. power.}$$

WHEEL AND AXLE.

Here the velocity of the power is to the velocity of the weight as the circumference of the wheel is to the circumference of the axle; hence, Divide the velocity of the power by the velocity of the weight, and the quotient is the weight that the power is equal to.

EXAMPLE 1.—A power equal to 30 lbs. is applied to the winch of a crane whose length is 15 inches; the pinion contains 10 teeth, the wheel 120, and the barrel is 9 inches diameter; required the weight raised.

$15 \times 2 \times 3.1416 = 94.248$ circumference of the circle described by the winch, or handle, $120 \div 10 = 12$ revolutions of the pinion for one of the wheel, and $3.1416 \times 9 = 28.2744$ the barrel's circumference; then,

$$\frac{94.248 \times 12 \times 30}{28.2744} = 1200 \text{ lbs. raised by this crane.}$$

EXAMPLE 2.—What would be the increase of power, in the last example, if a wheel of 150 teeth, and a pinion of 15, were added to the crane?

$150 \div 15 = 10$, that is, the velocity of the weight is diminished, while the velocity of the power is the same; then,

$$\frac{94.248 \times 12 \times 10 \times 30}{28.2744} = 12000 \text{ lbs. raised,}$$

the power being increased ten times.

EXAMPLE 3.—What power is requisite to raise 42 tons 60 feet high in 10 minutes, the velocity of the power being twenty feet per minute?

$60 \div 10 = 6$, and $\frac{\sqrt{42} \times 6}{20} = 12.6$ tons power.

TO CALCULATE FOR THE DIFFERENT PARTS OF A CRANE, AS RESPECTS MECHANICAL ADVANTAGE.

1.—*The number of revolutions of the pinion to one of the wheel, the length of the handle, and the force applied given, to find the diameter of the barrel.*

RULE.—Multiply the diameter of the circle described by the winch, or handle, in inches, by the power applied in lbs., and by the number of revolutions of the pinion to one of the wheel; divide the product by the weight to be raised in lbs., and the quotient is the barrel's diameter in inches.

EXAMPLE.—Suppose that two men were required to raise a weight of one ton, by a crane, and each man to exert a constant force of $33\frac{1}{2}$ lbs. on a handle 16 inches long, the pinion making seven revolutions for one of the wheel, what must be the barrel's diameter?

$16 \times 2 = 32$ inches, diameter of the circle described by the handle, and $33\frac{1}{2} \times 2 = 67$ lbs. constant force; then,

$$\frac{32 \times 67 \times 7}{2240} = 6.7 \text{ inches.}$$

2.—*The diameter of the barrel, the length of the handle, and force applied given, to find the number of revolutions of the pinion to one of the wheel.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle in inches, muliplied by the power applied in lbs., and the quotient is the revolutions of the pinion to one of the wheel.

EXAMPLE.—What must be the number of revolutions of the pinion to one of the wheel, when the power applied is 67 lbs., the length of the handle 16 inches,

and the barrel 6.7 inches diameter, to counterpoise a weight of one ton, or 2240 lbs ?

$$\frac{2240 \times 6.7}{32 \times 67} = 7 \text{ revolutions to one of the wheel.}$$

3.—*The diameter of the barrel, the number of revolutions of the pinion to one of the wheel, and the power applied given, to find the length of the handles.*

RULE.—Multiply the weight to be raised in lbs. by the barrel's diameter in inches, and divide the product by the power applied in lbs., multiplied by the number of revolutions of the pinion to one of the wheel, and half the quotient is the length of the handles.

EXAMPLE.—It is estimated that the united effort of two men at the handles of a crane is 67 lbs. nearly ; now a crane having a barrel of 6.7 inches diameter, and a pinion 7 to 1 of the wheel, what must be the length of handles to raise a weight of 1 ton ?

$$\frac{2240 \times 6.7}{67 \times 7} = \frac{32}{2} = 16 \text{ inches.}$$

4.—*The diameter of the barrel, the revolutions of the pinion to one of the wheel, and length of handles given, to find the power required.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle, multiplied by the revolutions of the pinion to one of the wheel, and the quotient is the power required.

EXAMPLE.—What power will be required to raise one ton by a crane, whose barrel is 6.7 inches diameter, the pinion 7 to 1 of the wheel, and each handle 16 inches long ?

$$\frac{2240 \times 6.7}{32 \times 7} = 67 \text{ lbs. power.}$$

NOTE.—The handles of a crane ought not to be less than 2 feet 11 inches, or 3 feet from the ground, and the jib to stand at an angle of about 45 degrees.

To find the thickness of cast iron for a crane post, when fixed at one end, and loaded at the other.

RULE.—Multiply the weight that the crane is to lift in lbs. by the leverage of the jib to one of the post, and by the length of the post in feet; divide the product by 168, then subtract the quotient from the cube of the outside diameter, and the cube root of the difference is the inside diameter.

EXAMPLE.—What thickness must the metal be for a crane post to carry a weight of 10 tons, the diameter of the post being 16 inches, and projecting 6 feet from the ground, the leverage of the jib being as $3\frac{1}{2}$ to 1 of the post?

10 tons = 22400 lbs.; then,

$$\frac{22400 \times 3.5 \times 6}{168} = 2800$$

the cube of 16 = 4096, and

$$4096 - 2800 = \sqrt[3]{1296} = 10.9$$

$$16 - 10.9 = \frac{5.1}{2} = 2\tfrac{1}{2} \text{ inches in thickness.}$$

THE PULLEY.

A single pulley, that only turns on its axis, and does not move out of its place, serves only to change the direction of the power, but gives no mechanical advantage. The advantage gained is always as twice the number of moveable pulleys, without taking any notice of the fixed pulleys necessary to compose the system of pulleys; hence, Divide the weight to be raised by twice the number of moveable pulleys, and the quotient is the power required to raise the weight, in terms of the same name.

EXAMPLE 1.—What power is requisite to raise 250lbs. with a pair of four-shieved blocks, the one block moveable and the other fixed?

$$4 \times 2 = 8, \text{ and } \frac{250}{8} = 31.25 \text{ lbs. power.}$$

EXAMPLE 2.—What weight will a power of 120 lbs. raise, when applied to a three and four-shieved block, the three being moveable and the other fixed?

$3 \times 2 = 6$, and $120 \times 6 = 720$ lbs. raised.

THE INCLINED PLANE.

The advantage gained by the inclined plane is as great as its length exceeds its perpendicular height; hence, when the power acts parallel to the plane, the length of the plane is to the weight as the height of the plane is to the power,—or, in other words, multiply the weight by the perpendicular height of the plane, and divide by its length, the quotient is the power that will support that weight upon the plane.

EXAMPLE 1.—Required the power, or equivalent weight, capable of supporting a load of 300 lbs. upon an inclined plane 50 feet long and 16 feet high.

50 is to 16 as 300 is to 96,

Or, $\frac{300 \times 16}{50} = 96$ lbs. power.

EXAMPLE 2.—A power of 120 lbs., with a velocity of 50 feet per minute, is to be applied to move a weight up an inclined plane at the rate of 30 feet per minute; the plane is 25 feet long and 8 feet high; required the weight that the power is equal to.

$120 \times 50 = 6000$, and $30 \times 8 = 240$; then,

As 240 : 25 :: 6000 : 625 lbs.

The weight multiplied by the length of the base, and divided by the length of the plane, equal the pressure on the plane.

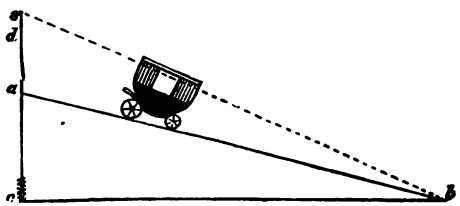
The space which a body describes upon an inclined plane, when descending by the force of gravity, is to the space which it would fall freely in the same time,

as the height is to the length of the plane, and the spaces being the same, the times will be inversely in this proportion.

Again, if two bodies descend from rest down two planes, equally inclined to the horizon, and then, without any loss of velocity, proceed to descend down two other inclined planes, also equally inclined to the horizon, the lengths of which are to each other in the same proportion as the lengths of the first two planes, the squares of the times of their whole motion will be in the same proportion as the lengths of the planes.

Means of ascertaining practically the effect produced by inclined planes.

Provide a board or box, *a b*, capable of holding pebbles, sand, &c., and which, by a screw, *c*, can be easily raised at one end, as *a d s*, &c.



When *a b* lies flat on *c b*, the carriage will be at rest; but by the screw at *c* raising *a b* leisurely, the carriage will, at a certain height, set off by itself, and run down the plane. Then are we in possession of a triangle that solves what force is necessary to drag any load of any kind on a road or level ground; for the hypotenuse *a b* represents the weight of the carriage, and the perpendicular *a c* what portion of that weight is necessary to draw the carriage on level ground, thus,

Suppose the carriage.... 12 cwt.
The line *a b* ..... 24 feet.
Height *c a*..... 3 feet.

The declivity, then, is as 3 to 24, or $\frac{1}{8}$. In this case it will be found that $\frac{1}{8}$ of the weight of the carriage would drag it on such a road or level ground, namely, $1\frac{1}{2}$ cwt.; but if the road were very deep and rough, it might require to be raised perhaps as high as *d* or *s*, before the carriage would set off. Now, if *c s* were half the length of *s b*, then it would require one-half the weight of the carriage to drag it on level ground, or, in the above case, 6 cwt.

This rule is universal, and has been proved by carriages at large, on roads of every description.

In estimating the draft up hill, the draft on the level must be added to it. Suppose the hill rises 1 foot in 4, then $\frac{1}{4}$ part of the weight must be added to the draft on level ground.

If the weight be, as before, 12 cwt., then $\frac{1}{4}$ would be 3 cwt.; and if its draft on a level were $1\frac{1}{2}$ cwt., then $4\frac{1}{2}$ cwt. would be the real draft necessary to draw 12 cwt. up a hill rising 1 foot in 4, &c.

EXAMPLE.—Suppose I find that, on an edge railway, a loaded carriage will just move by itself when there is a descent of $3\frac{1}{2}$ inches per chain, or about one perpendicular for 224 horizontal, which is (reckoning the carriage to weigh 1 ton) 10lbs. required to move it on a level. Now, from the above data, what force will be required to drag the same weight up a similar road ascending 1 inch per yard, or $\frac{1}{36}$? $\frac{1}{36}$ of a ton is $62\frac{8}{112}$ lbs., which added to 10 lbs. as above, amounts to $72\frac{8}{112}$ lbs., the weight required to drag it up an ascent of $1\frac{1}{36}$; and allowing the strength of an ordinary horse to be 140 lbs., he will only be able to drag $1\frac{9}{112}$, or say 2 tons up an ascending plane of 1 in 36.

THE WEDGE.

As the wedge is seldom used without being driven, the force of the blow is not easily ascertained; of course, in practice it is not worth taking into account *with respect* to calculation.

THE SCREW.

The advantage gained by the screw is as much as the circumference of a circle, described by the lever or handle, exceeds the interval or distance between the spirals of the screw; hence, as the circumference of the circle described by the handle is to the pitch of the screw, so is the weight to the power.

EXAMPLE.—What power is necessary to raise a weight of 6000 lbs., the length of the lever being 20 inches, and the screw $\frac{3}{4}$ pitch?

$20 \times 2 = 40 \times 3.1416 = 125.6$ inches; then,
As 125.6 : .75 :: 6000 : 35.8 lbs., power required.

NOTE.—There are few machines but what, on account of the friction of the parts against one another, will require a third part more power to work them, when loaded, than is requisite to constitute a balance between power and weight.

The following Table shows the estimated power of man or horse as applied to machinery.

Application of the power.	Lbs. Avr. at the rate of 220 feet ℘ minute.	Lbs. Avr. at the rate of one foot ℘ minute.
A man is supposed to be capable of lifting or carrying..... ...	27.273 or	6000
A man is supposed to be capable of turning the winch of a crane with a force equal to..... ...	28.637 or	6300
When the united efforts of two men are applied to the winch of a crane, the handles being at right angles, each man exerts a force equal to	33.499 or	7350
A man is supposed to exert a power in pumping equal to	17.335 or	3814
In ringing, a man exerts a force equal to	38.955 or	8570
And in rowing	40.955 or	9010
The power of a horse equal to	150 or	33000

OF FALLING BODIES.

In bodies falling freely by their own weight, their velocities are as the times, and the spaces as the square of the times; therefore, if the times be as the numbers .....1, 2, 3, 4, &c.
The velocities will be also .....1, 2, 3, 4, &c.
The spaces passed through .....1, 4, 9, 16, &c.
And the spaces for each time, as the odd numbers .....1, 3, 5, 7, &c.

It has been ascertained by experiment that a body falling freely from rest will descend through $16\frac{1}{12}$ feet in the first second of time, and will then have acquired a velocity which, being continued uniformly, will carry it through $32\frac{2}{12}$ feet in the next second, consequently, if the first series of numbers be expressed in seconds,

	1″	2″	3″
Velocities in feet will be	$32\frac{2}{12}$	$64\frac{4}{12}$	$96\frac{1}{2}$, &c.
Spaces in the whole times	$16\frac{1}{12}$	$64\frac{4}{12}$	$144\frac{3}{4}$, &c.
And the spaces for each second.	$16\frac{1}{12}$	$48\frac{1}{4}$	$80\frac{3}{12}$, &c.

To find the velocity a falling body will acquire in any given time.

RULE.—Multiply the time in seconds by 32.166, and the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity in 7 seconds.

$32.166 \times 7 = 225.162$ feet, velocity acquired.

To find the velocity a body will acquire by falling from any given height.

RULE.—Multiply the space in feet by 64.33, and the square root of the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity a ball will acquire in descending through 201 feet.

$$\sqrt{64.33} \times 201 = 113.7 \text{ feet.}$$

To find the space through which a body will fall in any given time.

RULE.—Multiply the square of the time in seconds by 16.083, and the product will be the space in feet.

EXAMPLE.—Required the space fallen through in 7 seconds.

$$16.083 \times 49 = 788.067 \text{ feet.}$$

NOTE.—The velocity acquired by a body in falling from rest, through a given height, is the same whether it fall freely or descend through a plane any way inclined.

The diameter of a circle perpendicular to the horizon, and any chord terminating at either extremity of that diameter, are fallen through in the same time.

And the velocities which bodies acquire by descending along chords of the same circle are as the lengths of those chords.

TABLE

Of accelerated motion of falling bodies.

Time in seconds of the body's fall.	Space fallen through during each second in feet.	Whole space fallen through in feet.	Velocity acquired at the end of the time.
1	16.095	16.095	32.19
2	48.285	64.380	64.38
3	80.475	144.855	96.57
4	112.665	257.520	128.76
5	144.855	402.375	160.95
6	177.045	579.420	193.14
7	209.235	788.655	225.33
8	241.425	1030.080	257.52
9	273.615	1303 695	289.71
10	305.805	1609.495	321.90

ON PENDULUMS.

A pendulum that vibrates seconds, or 60 in the latitude of London, is 39.1393 inches long; and $\sqrt{39.1393} \times 60 = 375.36$, which serves as a constant number for other pendulums; thus, 375.36, divided by the square root of the pendulum's length, gives the number of vibrations per minute; and divided by the vibrations per minute, gives the square root of the length of pendulums.

EXAMPLE 1.—Required the number of vibrations a pendulum of 25 inches long will make per minute.

$$\frac{375.36}{\sqrt{25}} = 75.072 \text{ vibrations per minute.}$$

EXAMPLE 2.—Required the length of a pendulum to make 80 vibrations per minute.

$$\frac{375.36}{80} = 4.692^2 = 22.014864 \text{ inches long.}$$

Table containing the length of pendulums to vibrate seconds in various parts of the world.

At Sierra Leone	39.01954 in.	At New York	39.10153 in.
" Trinidad	39.01879 "	" Bordeaux	39.11282 "
" Madras	39.02630 "	" Paris	39.12843 "
" Jamaica	39.03508 "	" Edinburgh	39.15540 "
" Rio Janiero	39.01206 "	" Greenland	39.20328 "

A pendulum vibrating half seconds in the latitude of London is 9.8 inches in length; and for quarter seconds 2.5 inches.

ON THE VELOCITY OF WHEELS, DRUMS, PULLEYS, &c.

When wheels are applied to communicate motion from one part of a machine to another, their teeth act alternately on each other; consequently, if one wheel contains 60 teeth and another 20, the one containing 20 teeth will make three revolutions, while the other makes but one; and if drums or pulleys are taken in place of wheels, the result will be the same; because their circumferences, describing equal spaces, render their revolutions unequal: from this the rule is derived, namely,

Multiply the velocity of the driver by the number of teeth it contains, and divide by the velocity of the driven; the quotient will be the number of teeth it ought to contain. Or, Multiply the velocity of the driver by its diameter, and divide by the velocity of the driven; the quotient will be the diameter of the driven.

EXAMPLE 1.—If a wheel that contains 75 teeth makes 16 revolutions per minute, required the number of teeth in another to work in it, and make 24 revolutions in the same time.

$$\frac{75 \times 16}{24} = 50 \text{ teeth.}$$

EXAMPLE 2.—A wheel, 64 inches diameter, and making 42 revolutions per minute, is to give motion to a shaft at the rate of 77 revolutions in the same time: required the diameter of a wheel suitable for that purpose.

$$\frac{64 \times 42}{77} = 34.9 \text{ inches.}$$

EXAMPLE 3.—Required the number of revolutions per minute made by a wheel or pulley 20 inches diameter, when driven by another of 4 feet diameter, and making 46 revolutions per minute.

$$\frac{48 \times 46}{20} = 110.4 \text{ revolutions.}$$

EXAMPLE 4.—A shaft, at the rate of 22 revolutions per minute, is to give motion, by a pair of wheels, to another shaft at the rate of $15\frac{1}{2}$; the distance of the shafts from centre to centre is $45\frac{1}{2}$ inches; the diameters of the wheels at the pitch lines are required.

$$\frac{45.5 \times 15.5}{22 + 15.5} = 18.81 \text{ radius of the driving wheel.}$$

$$\text{And } \frac{45.5 \times 22}{22 + 15.5} = 26.69 \text{ radius of the driven wheel.}$$

EXAMPLE 5.—Suppose a drum to make 20 revolutions per minute, required the diameter of another to make 58 revolutions in the same time.

$58 \div 20 = 2.9$, that is, their diameters must be as 2.9 to 1; thus, if the one making 20 revolutions be called 30 inches, the other will be $30 \div 2.9 = 10.345$ inches diameter.

EXAMPLE 6.—Required the diameter of a pulley, to make $12\frac{1}{2}$ revolutions in the same time as one of 32 inches making 26.

$$\frac{32 \times 26}{12.5} = 66.56 \text{ inches diameter.}$$

EXAMPLE 7.—A shaft, at the rate of 16 revolutions per minute, is to give motion to a piece of machinery at the rate of 81 revolutions in the same time; the motion is to be communicated by means of two wheels and two

pulleys with an intermediate shaft; the driving wheel contains 54 feet, and the driving pulley is 25 inches diameter; required the number of teeth in the other wheel, and the diameter of the other pulley.

$\sqrt{81 \times 16} = 36$, the mean velocity between 16 and 81; then, $\frac{16 \times 54}{36} = 24$ teeth; and $\frac{36 \times 25}{81} =$ 11.11 inches, diameter of pulley.

EXAMPLE 8.—Suppose in the last example the revolutions of one of the wheels to be given, the number of teeth in both, and likewise the diameter of each pulley, to find the revolutions of the last pulley.

$\frac{16 \times 54}{24} = 36$, velocity of the intermediate shaft;

and $\frac{36 \times 25}{11.11} = 81$, the velocity of the machine.

TABLE

For finding the radius of a wheel when the pitch is given, or the pitch of a wheel when the radius is given, that shall contain from 10 to 150 teeth, and any pitch required.

Num. of Teeth.	Radius.	Num. of Teeth.	Radius.	Num. of Teeth.	Radius.	Num. of Teeth.	Radius.
10	1.618	46	7.327	81	12.895	116	18.464
11	1.774	47	7.486	82	13.054	117	18.623
12	1.932	48	7.645	83	13.213	118	18.782
13	2.089	49	7.804	84	13.370	119	18.941
14	2.247	50	7.963	85	13.531	120	19.101
15	2.405	51	8.122	86	13.690	121	19.260
16	2.563	52	8.281	87	13.849	122	19.419
17	2.721	53	8.440	88	14.008	123	19.578
18	2.879	54	8.599	89	14.168	124	19.737
19	3.038	55	8.758	90	14.327	125	19.896
20	3.196	56	8.917	91	14.486	126	20.055
21	3.355	57	9.076	92	14.645	127	20.214
22	3.513	58	9.235	93	14.804	128	20.374
23	3.672	59	9.394	94	14.963	129	20.533
24	3.830	60	9.553	95	15.122	130	20.692
25	3.989	61	9.712	96	15.281	131	20.851
26	4.148	62	9.872	97	15.440	132	21.010
27	4.307	63	10.031	98	15.600	133	21.169
28	4.465	64	10.190	99	15.759	134	21.328
29	4.624	65	10.349	100	15.918	135	21.488
30	4.788	66	10.508	101	16.077	136	21.647
31	4.942	67	10.667	102	16.236	137	21.806
32	5.101	68	10.826	103	16.395	138	21.965
33	5.260	69	10.985	104	16.554	139	22.124
34	5.419	70	11.144	105	16.713	140	22.283
35	5.578	71	11.303	106	16.873	141	22.442
36	5.737	72	11.463	107	17.032	142	22.602
37	5.896	73	11.622	108	17.191	143	22.761
38	6.055	74	11.781	109	17.350	144	22.920
39	6.214	75	11.940	110	17.509	145	23.079
40	6.373	76	12.099	111	17.668	146	23.238
41	6.532	77	12.258	112	17.827	147	23.397
42	6.691	78	12.417	113	17.987	148	23.556
43	6.850	79	12.576	114	18.146	149	23.716
44	7.009	80	12.735	115	18.305	150	23.875
45	7.168						

RULE.—Multiply the radius in the table by the pitch given, and the product will be the radius of the wheel required.

Or, Divide the radius of the wheel by the radius in the table, and the quotient will be the pitch of the wheel required.

EXAMPLE 1.—Required the radius of a wheel to contain 64 teeth, of 3 inch pitch.

$$10.19 \times 3 = 30.57 \text{ inches.}$$

EXAMPLE 2.—What is the pitch of a wheel to contain 80 teeth, when the radius is 25.47 inches?

$$25.47 \div 12.735 = 2 \text{ inch pitch.}$$

Or, set off upon a straight line seven times the pitch given, divide that, or another exactly the same length, into eleven equal parts; call each of those divisions four, or each of those divisions will be equal to four teeth upon the radius.

EXAMPLE.—Were it required to find the diameter of a wheel to contain 21 teeth, the construction would be as follows:—

1		2		3		4		5		6	7
1	2	3	4	5	6	7	8	9	10	11	

<...4.....8....12.....16...20>

Thus, 5 divisions and $\frac{1}{4}$ of another equal the radius of the wheel.

Regular approved proportions for wheels with flat arms in the middle of the ring, and ribs, or feathers, on each side.

The length of the teeth = $\frac{6}{5}$ the pitch, besides clearance, or $\frac{5}{7}$ the pitch, clearance included.

Thickness of the teeth	$\frac{4}{5}$ the pitch.
Breadth on the face 2	$\frac{1}{4}$,,
Edge of the rim	$\frac{4}{5}$,,
Rib projecting inside the rim	$\frac{1}{5}$,,
Thickness of the flat arms	$\frac{4}{5}$,,

Breadth of the arms at the points = 2 teeth and $\frac{1}{4}$ the pitch, getting broader towards the centre of the wheel in the proportion of $\frac{1}{4}$ inch to every foot in length.

Thickness of the ribs, or feathers, $\frac{1}{4}$ the pitch.

Thickness of metal round the eye, or centre, $\frac{1}{5}$ the pitch.

Wheels made with plain arms, the teeth are in the same proportion as above; the ring and the arms are each equal to one cog or tooth in thickness, and the metal round the eye same as above, in feathered wheels.

To find the power that a cast iron wheel is capable of transmitting at any given velocity.

RULE.—Multiply the breadth of the teeth, or face of the wheel in inches, by the square of the thickness of one tooth, and divide the product by the length of the teeth, the quotient is the strength in horses' power at a velocity of 136 feet per minute.

EXAMPLE.—Required the power that a wheel of the following dimensions ought to transmit with safety, namely,

Breadth of teeth.....$7\frac{1}{2}$ inches,
Thickness 1.4
And length.....2

$1.4^2 = 1.96$, and $\frac{7.5. \times 1.96}{2} = 7.35$ horses' power.

The strength at any other velocity is found by multiplying the power so obtained by any other required velocity, and by .0044, the quotient is the power at that velocity.

Suppose the wheel as above, at a velocity of 320 feet per minute.

7.35 × *320* × .0044 = 10.3488 horses' power.

ON THE MAXIMUM VELOCITY AND POWER OF WATER WHEELS.

Since publishing the first edition of this work, I have endeavoured, as far as possible, to acquire the most improved practical principles of water wheels as a moving power; and

1.—*Of undershot wheels.*

The term "undershot" is applied to a wheel when the water strikes at, or below, the centre. And the greatest effect is produced when the periphery of the wheels moves with a velocity of .57 that of the water; —hence, to find the velocity of the water, multiply the square root or the perpendicular height of the fall in feet by 8, and the product is the velocity in feet per second.

EXAMPLE.—Required the maximum velocity of an undershot wheel, when propelled by a fall of water 6 feet in height.

$\sqrt{6} = 2.45 \times 8 = 19.6$ feet velocity of water.

And $19.6 \times .57 = 11.17$ feet per second for the wheel.

2.—*Of breast and overshot wheels.*

Wheels that have the water applied between the centre and the vertex are styled breast wheels, and overshot when the water is brought over the wheel and laid on the opposite side; however, in either case the maximum velocity is $\frac{2}{3}$ that of the water; hence, to find the head of water proper for a wheel at any velocity, say,

As the square of 16.083, or 258.67, is to 4, so is the

square of the velocity of the wheel in feet per second to the head* of water required.

EXAMPLE.—Required the head of water necessary for a wheel of 24 feet diameter, moving with a velocity of 5 feet per second.

$$\frac{5 \times 3}{2} = 7.5 \text{ feet velocity of the water.}$$

And $258.67 : 4 :: 7.5^2 : .87$ feet, head of water required.

But one-tenth of a foot of head must be added for every foot of increase in the diameter of the wheel, from 15 to 20 feet, and .05 more for every foot of increase from 20 to 30 feet, commencing with five-tenths for a 15 feet wheel.

This additional head is intended to compensate for the friction of water in the aperture of the sluice to keep the velocity as 3 to 2 of the wheel; thus, in place of .87 feet head for a 24 feet wheel, it will be $.87 + 1.2 = 2.07$ feet head of water.

If the water flow from under the sluice, multiply the square root of the depth in feet by 5.4, and by the area of the orifice also in feet, and the product is the quantity discharged in cubic feet per second.

Again, if the water flow over the sluice, multiply the square root of the depth in feet by 5.4; and $\frac{2}{3}$ of the product multiplied by the length and depth, also in feet, gives the number of cubic feet discharged per second nearly.

EXAMPLE 1.—Required the number of cubic feet per second that will issue from the orifice of a sluice 5 feet long, 9 inches wide, and 4 feet from the surface of the water.

$$\sqrt{4} = 2 \times 5.4 = 10.8 \text{ feet velocity,}$$

And $5 \times .75 \times 10.8 = 40.5$ cubic feet per second.

* By *head* is understood the distance between the aperture of the sluice *and where* the water strikes upon the wheel.

EXAMPLE 2.—What quantity of water per second will be expended over a wear, dam, or sluice, whose length is 10 feet, and depth 6 inches?

$$\sqrt{.5} = .2236 \times 5.4 = \frac{1.20744 \times 2}{3} = .80496$$

feet velocity; then $10 \times .5 = 5$ feet, and $.80496 \times 5 = 4.0248$ cubic feet per second nearly.

In estimating the power of water wheels, half the head must be added to the whole fall, because 1 foot of fall is equal to 2 feet of head; call this the effective perpendicular descent; multiply the weight of the water per second by the effective perpendicular descent and by 60; divide the product by 33,000, and the quotient is the effect expressed in horses' power.

EXAMPLE 1.—Given 16 cubic feet of water per second, to be applied to an undershot wheel, the head being 12 feet, required the power produced.

$$12 \div 2 = 6 \text{ and } \frac{6 \times 16 \times 62.5 \times 60}{33000} = 10.9$$

horses' power nearly.

EXAMPLE 2.—Given 16 cubic feet of water per second, to be applied to a high breast or an overshot wheel, with 2 feet head and 10 feet fall; required the power.

$$2 \div 2 = 1 \text{ and } \frac{1 + 10 \times 16 \times 62.5 \times 60}{33000} = 20$$

horses' power.

N.B.—Only about two-thirds of the above results can be taken as real communicative power to machinery.

OF THE CIRCLE OF GYRATION IN WATER WHEELS.

The centre or circle of gyration is that point in a revolving body into which, if the whole quantity of matter were collected, the same moving force would generate the same angular velocity, which renders it of the utmost importance in the erection of water wheels, and the motion ought always to be communicated from that point when it is possible.

To find the circle of gyration.

RULE.—Add into one sum twice the weight of the shrouding, buckets, &c., multiplied by the square of the radius, $\frac{2}{3}$ of the weight of the arms, multiplied by the square of the radius, and the weight of the water multiplied by the square of the radius also; divide the sum by twice the weight of the shrouding, arms, &c., added to the weight of the water, and the square root of the quotient is the distance of the circle of gyration from the centre of suspension nearly.

EXAMPLE.—Required the distance of the centre of gyration from the centre of suspension in a water wheel 22 feet diameter, shrouding, buckets, &c., = 18 tons, arms = 12 tons, and water = 10 tons.

$$\begin{array}{rrrrrr} 22 \div 2 = 11 & \text{and} & 11^2 = & & 121 \\ \text{Then, } 18 \times 2 = 36 & \times & 121 = & & 4356 \\ \frac{2}{3} \text{ of } 12 = 8 & \times & 121 = & & 968 \\ \text{water} = 10 & \times & 121 = & & 1210 \\ & & & & \overline{6534} \end{array}$$

And $\overline{18 + 12} \times 2 = 60 + 10 = 70$; hence,

$\sqrt{\frac{6534}{\quad}} = 9.6$ feet from the centre of suspension nearly.

Table of angles for windmill sails.

The radius is supposed to be divided into six equal parts, and $\frac{1}{6}$ from the centre is called 1, the extremity being denoted by 6.

No.	*Angle with the Plane of Motion.*	
1	18°	24°
2	19	21
3	18	18
4	16	14
5	12½	9
6	7	3 *extremity.*

The first column contains the angles according to Smeaton; but experience has taught us that the angles in the second column are preferable.

THE VELOCITY OF THRASHING MACHINES, MILLSTONES, BORING IRON, &C.

The drum or beaters of a thrashing machine ought to move with a velocity of about 3000 feet per minute; hence, divide 11460 by the diameter of the drum in inches; or 955 by the diameter of the drum in feet; and the quotient is the number of revolutions required per minute. And

The feeding rollers must make half the revolutions of the drum, when their diameters are about 3½ inches.

If the machine is driven by horses, their velocity ought to be from 2½ to 3 times round a 24 feet ring per minute.

Divide 500 by the diameter of a millstone, in feet, or 6000 by the diameter in inches, and the quotient is the number of revolutions required per minute.

In boring cast iron the cutters ought to have a velocity of about 108 inches per minute, or divide 36 by the diameter in inches, the quotient is the number of revolutions of the boring head per minute.

And divide 100 by the diam. in inches, the quotient is the number of revolutions per minute, for turning wrought iron in general, and about half that velocity for cast iron.

OF PUMPS AND PUMPING ENGINES.

Pumps are chiefly designated by the names of lifting and force pumps: lifting pumps are applied to wells, &c., where the height of the bucket, from the surface of the water, must not exceed 33 feet; this being nearly equal to the pressure of the atmosphere, or the height to which water would be forced up into a vacuum by the pressure of the atmosphere. Force pumps are applicable on all other occasions, as raising water to any required height, supplying boilers against the force of the steam, hydrostatic presses, &c.

The power required to raise water to any height is as the weight and velocity of the water with an addition of about $\frac{1}{5}$ of the whole power for friction; hence the rule,—Multiply the perpendicular height of the water, in feet, by the velocity, also in feet, and by the square of the pump's diameter in inches, and again by .341; (this being the weight of a column of water 1 inch diameter, and 12 inches high, in lbs. avoirdupois;) divide the product by 33,000, and $\frac{1}{5}$ of the quotient added to the whole quotient, will be the number of horses' power required.

EXAMPLE.—Required the power necessary to overcome the resistance and friction of a column of water 4 inches diameter, 60 feet high, and flowing with a velocity of 130 feet per minute.

$$\frac{60 \times 130 \times 4^2 + .341}{33000} = \frac{1.3}{5} = .26 + 1.3 = 156$$

horses' power nearly.

NOTE.—Hot liquor pumps, or pumps to be employed in raising any fluid where steam is generated, require to be placed in the fluid, or as low as the bottom of it, on account of the steam filling the pipes, and acting as a counterpoise to the atmosphere; and the diameter of the pipes to and from a pump ought not to be less than $\frac{1}{3}$ of the pump's diameter.

The diameter of a pump and velocity of the water given, to find the quantity discharged in gallons, or cubic feet, in any given time.

RULE.—Multiply the velocity of the water, in feet per minute, by the square of the pump's diameter in inches, and by .034 for imperial gallons ; or, .0005454 for cubic feet, and the product will be the number of gallons, or cubic feet, discharged in the given time nearly.

EXAMPLE.—What is the number of imperial gallons of water discharged per hour by a pump 4 inches diameter, the water flowing at the rate of 130 feet per minute ?

$$130 \times 60 = 7800 \text{ feet per hour.}$$
$$\text{And, } 7800 \times 4^2 \times .034 = 4243.2 \text{ gallons.}$$

The length of stroke and number of strokes given, to find the diameter of a pump, and number of horses' power that will discharge a given quantity of water in a given time.

RULE 1.—Multiply the number of imperial gallons required, in the given time, by 353, or the number of cubic feet by 2201, and divide the product by the velocity of the water, in inches, and the square root of the quotient will be the pump's diameter, in inches.

2.—Multiply the number of gallons per minute by 10, or the number of cubic feet by 62.5, and by the perpendicular height of the water in feet, divide the product by 33,000, then will $\frac{1}{5}$ of the quotient, added to the whole quotient, be the number of horses' power required.

EXAMPLE.—Required the diameter of a pump, and number of horses' power, capable of filling a cistern 20 feet long, 12 feet wide, and $6\frac{1}{2}$ feet deep, in 45 minutes.

whose perpendicular height is 53 feet; the pump to have an effective stroke of 26 inches, and make 30 strokes per minute.

$$20 \times 12 \times 6.5 = 1560 \text{ cubic feet, and}$$

$$\frac{1560}{45} = 34.66 \text{ cubic feet per minute.}$$

$$\text{Then, } \frac{34.66 \times 2201}{\sqrt{26 \times 30}} = 9.89 \text{ inches diameter of pump.}$$

$$\text{And } \frac{34.66 \times 62.5 \times 53}{33000} = \frac{3.48}{5} = .69 + 3.48 = 4.17$$

horses' power.

To find the time a cistern will take in filling, when a known quantity of water is going in, and a known portion of that water is going out, in a given time.

RULE.—Divide the content of the cistern, in gallons, by the difference of the quantity going in, and the quantity going out, and the quotient is the time in hours and parts that the cistern will take in filling.

EXAMPLE.—If 30 gallons per hour run in and 22½ gallons per hour run out of a cistern capable of containing 200 gallons, in what time will the cistern be filled?

$30 - 22.5 = 7.5$, and $200 \div 7.5 = 26.666$, or 26 hours and 40 minutes.

To find the time a vessel will take in emptying itself of water.

Mr. Banks ascertained, from very accurate experiments, that a vessel, 3.166 feet long and 2.705 inches diameter, would empty itself in 3 minutes and 16 seconds, through an orifice in the bottom, whose area

is .0141 inches; and another 6.458 feet long, the diameter and orifice, as before, would do the same in 4 minutes and 40 seconds; hence, from these experiments, a rule is obtained, namely,

Multiply the square root of the depth in feet by the area of the falling surface in inches, divide the product by the area of the orifice, multiplied by 3.7, and the quotient is the time required in seconds, nearly.

EXAMPLE.—How long will it require to empty a vessel of water, 9 feet high, and 20 inches diameter, through a hole $\frac{3}{4}$ inch in diameter?

$\sqrt{9} = 3$, the square root of the depth,
314.16 inches, area of the falling surface,
.4417 inches, area of the orifice;

Then, $\frac{314.16 \times 3}{.4417 \times 3.7} = 576.7$ seconds, or
9 minutes and 36 seconds.

On the pressure of fluids.

The side of any vessel containing a fluid sustains a pressure equal to the area of the side, multiplied by half the depth; thus,

Suppose each side of a vessel to be 12 feet long and 5 feet deep, when filled with water, what pressure is upon each side?

$12 \times 5 = 60$ feet, the area of the side,
2.5 feet = half the depth, and
62.5 lbs. = the weight of a cubic foot of water.

Then, $60 \times 2.5 \times 62.5 = 9375$ lbs.

To find the number of imperial gallons contained in a yard of pipe of any given diameter.

RULE.—Square the diameter of the pipe in inches, cut off one integer for a decimal; again, multiply the square by 2, the product is hundredths, &c., of a

gallon, which add to the former product, and the sum will be the content of the pipe in imperial gallons nearly.

EXAMPLE 1.—Required the number of imperial gallons contained in each yard of a $6\frac{1}{4}$ inch pipe.

$6.25^2 = 39.0625$ and $3.90625 \times 2 = 78125$.

Then, 3.90625

$+ \quad 78125$

$= 3.984375$ gallons.

EXAMPLE 2.—Required the content of a yard of 4 inch pipe in imperial gallons.

$4^2 = 16$, and $16 \times 2 = 32$, then 1.6

$+ \quad 32$

$= 1.632$ gallons.

To find the weight that a given power can raise by one of Bramah's pumps, or hydrostatic presses.

RULE.—Multiply the square of the diameter of the ram in inches by the power applied in lbs., and by the effective leverage of the pump handle; divide the product by the square of the pump's diameter, also in inches, and the quotient is the weight that the power is equal to.

EXAMPLE.—What weight will a power of 50 lbs. raise by means of an hydrostatic press, whose ram is 7 inches diameter, pump $\frac{7}{8}$, and the effective leverage of the pump handle being as 6 to 1?

$$\frac{7^2 \times 50 \times 6}{.875^2} = 19200 \text{ lbs., or 8 tons 11 cwt.}$$

In the following rules for pumping engines the boiler is supposed to be loaded with about $2\frac{1}{2}$ lbs. per square inch, and the barometer attached to the condenser indicating 26 inches on an average, or 13 lbs., $= 15\frac{1}{2}$ lbs., from which deduct $\frac{1}{4}$ for friction, leaves a pressure of 10 lbs. nearly upon each square inch of the piston.

To find the diameter of a cylinder to work a pump of a given diameter for a given depth.

RULE.—Multiply the square of the pump's diameter in inches by $\frac{1}{3}$ of the depth of the pit in fathoms, and the square root of the product will be the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder to work a pump 12 inches diameter and 27 fathoms deep.

$$\sqrt{12^2 \times 9} = 36 \text{ inches diameter.}$$

To find the diameter of a pump that a cylinder of a given diameter can work at a given depth.

RULE.—Divide three times the square of the cylinder's diameter in inches by the depth of the pit in fathoms, and the square root of the quotient will be the pump's diameter in inches.

EXAMPLE.—What diameter of a pump will a 36 inch cylinder be capable of working 27 fathoms deep?

$$\sqrt{\frac{36^2 \times 3}{27}} = 12 \text{ inches diameter.}$$

To find the depth from which a pump of a given diameter will work by means of a cylinder of a given diameter.

RULE.—Divide three times the square of the cylinder's diameter in inches by the square of the pump's diameter also in inches, and the quotient will be the depth of the pit in fathoms.

EXAMPLE.—Required the depth that a cylinder of 36 inches diameter will work a pump of 12 inches diameter.

$$\sqrt{\frac{36^2 \times 3}{144}} = 27 \text{ fathoms.}$$

APPROXIMATE RULES FOR CALCULATING LIQUIDS.

To find the number of imperial gallons contained in any square or rectangular cistern.

RULE.—Multiply the content of the cistern in cubic feet by 6.232, or the content in cubic inches by .003607, and the product is the number of gallons nearly.

EXAMPLE 1.—A cistern that is 8 feet long, $4\frac{1}{2}$ feet wide, and 3 feet deep, required its contents in imperial gallons.

$8 \times 4.5 \times 3 = 108$ cubic feet,
And $108 \times 6.232 = 673.056$ gallons.

Or, 8 feet = 96 inches; $4\frac{1}{2}$ feet = 54 inches; and 3 feet = 36 inches; then,

$96 \times 54 \times 36 = 186624$ cubic inches,
And $186624 \times .003607 = 673.152$ gallons.

Any two dimensions of a square or rectanglar cistern being given, to find the third, that shall contain any number of imperial gallons required.

RULE.—Divide the number of gallons that the cistern is required to contain by the product of the two dimensions multiplied by either of the multipliers as above, according as the dimensions are given in feet or inches, and the quotient will be the third dimensions of the cistern nearly.

EXAMPLE.—Required the depth of a cistern to contain 800 imperial gallons, the length being $6\frac{1}{2}$ feet, and width $4\frac{3}{4}$ feet.

$6.5 \times 4.75 \times 6.232 = 192.413$; and
$800 \div 192.413 = 4.16$ feet deep.

To find the content of a cylinder in imperial gallons.

RULE.—Multiply the square of the diameter in feet by the length of the cylinder, also in feet, and by 4.895;

Or, the square of the diameter in inches by the length in feet and by 0.34;

Or, the square of the diameter in inches by the length also in inches, and by .002832, and the product will be the content in gallons nearly.

EXAMPLE.—How many imperial gallons are contained in a well $22\frac{1}{2}$ feet deep, and $3\frac{1}{2}$ feet diameter?

$3.5^2 \times 22.5 \times 4.895 = 1349.18$ gallons.

Or, $3\frac{1}{2}$ feet $= 42$ inches,

And, $42^2 \times 22.5 \times .034 = 1349.46$ gallons.

Also, $22\frac{1}{2}$ feet $= 270$ inches,

And, $42^2 \times 270 \times .002832 = 1349.3$ gallons.

The length of a cylinder given, to find the diameter, or the diameter given, to find the length that shall contain any number of imperial gallons required.

RULE.—Divide the number of gallons that the cylinder is required to contain, by the length in feet multiplied by 4.895, and the square root of the quotient is the diameter in feet, and parts of a foot;

Or, divide the number of gallons by the square of the diameter in feet multiplied by 4.895, and the quotient is the length in feet and parts of a foot,—and

If the dimensions are in inches in place of feet, use 354 in place of 4.895.

EXAMPLE.—What must be the diameter of a cylinder to contain 5 imperial gallons, when the length is 20 inches?

$$\sqrt{\frac{354 \times 5}{20}} = 9.4 \text{ inches diameter.}$$

The cube of the diameter of a sphere in feet, multiplied by 3.263 = imperial gallons ;

Or, the cube of the diameter of a sphere in inches, multiplied by .001888 = imperial gallons

NOTE.—The weight of a cubic foot of water = 62.5 lbs. avoirdupois.

Weight of a cubic inch = .03617 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch square = .434 lbs. avoirdupois.

Weight of a cylindrical foot of water = 49.1 lbs. avoirdupois.

Weight of a cylindrical inch = .02842 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch diameter = .341 lbs. avoirdupois.

Take for example a column of water 11 inches diameter and 15 feet high, required its weight.

$11^2 \times 15 \times .341 = 618\,915$ lbs. avoirdupois.

11.2 imperial gallons of water = 1 cwt.

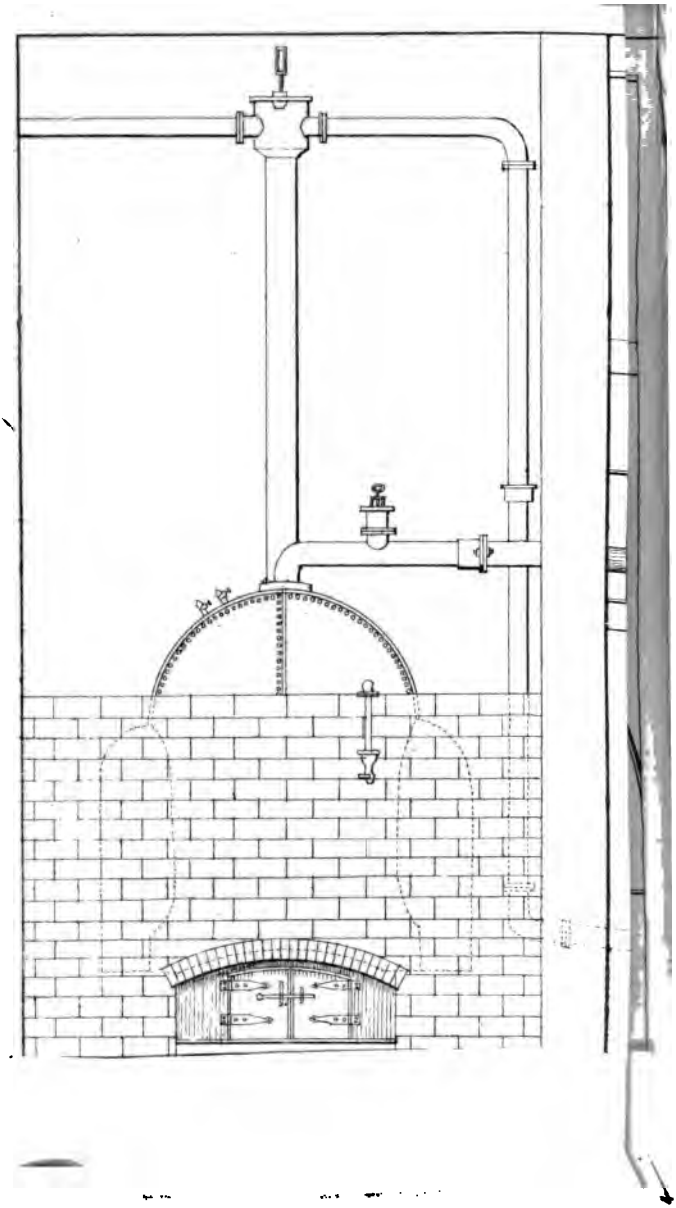
224 imperial gallons of water = 1 ton.

1.8 cubic feet of water ..... = 1 cwt.

35.84 .... = 1 ton.

1 .... = 6¼ imperial gallons.

1 cylindrical foot ..... = 5 imperial gallons.



OF STEAM AND THE STEAM ENGINE.

Steam is the visible moist vapour which arises from all bodies that contain juices easily expelled from them by heats not sufficient for their combustion.

But steam, as applicable at present to the steam-engine, is highly rarified water, the particles of which are expanded by the absorption of caloric, or the matter of heat.

Water rises in vapour at all temperatures, but is confined to the surface of the fluid acted upon until it has attained 212° Fahrenheit, called the boiling point; at that heat steam ascends through it, preventing its elevation to a higher temperature by carrying the heat off in a latent form.

The latent heat of steam at the common pressure of the atmosphere, according to very accurate experiments, is found to be 1000°; and we know that the sensible, or thermometric heat = 212°. Now 212° − 32° =180° and 1000 + 180 = 1180°; therefore, steam at 212° is highly rarified water, containing 1180° of heat; hence, to find the latent heat of steam at any other temperature, subtract the sensible heat from 1180°, and the difference + 32° = the latent heat.

EXAMPLE.—Required the latent heat of steam whose sensible heat is 224°.

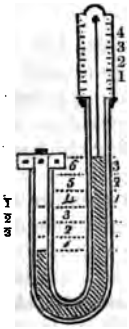
1180 − 224 = 956,

And 956 + 32 = 988° latent heat.

One cubic inch of water produces about 1700 cubic inches of steam at 212°, or the common pressure of the atmosphere; but the boiling point varies considerably, according to the pressure on the surface of the fluid, and, of course, materially affects the density of the vapour produced; thus, in a vacuum, water boils at about 90°; under common pressure, at 212°; and when pressed with a column of mercury 5 inches in height, will not boil

until heated to 217°; each inch of mercury producing by its pressure a rise of about 1° in the thermometer.

The pressure or force of steam in the boiler (less than the weight upon the safety valve) is generally indicated by a column of mercury in a bent iron tube, which causes the range of the float to be only half the range of the mercury, 2 inches of mercury being nearly equal to 1 lb. pressure of steam in the boiler, thus :—

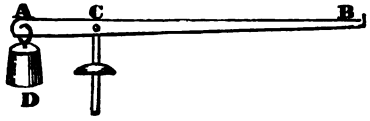


Each inch of the float indicates a pressure of 1lb. nearly.

—Level of the mercury when there is no presssure of steam.

To calculate the effect of a lever and weight upon the safety valve of a steam boiler, &c.

The lever, in all cases, is supposed to be made finished, and balanced, by a known weight or weights, on the short end, making that point where it rests, or is attached to the valve, the centre of motion ; then that weight, added to the weight of the lever, is the effective weight upon the valve, independent of any other additional weight, thus :—



Then there are three different ways that it may be required to calculate the lever.

1.—*When a certain pressure may be required upon the valve, the distance of the weight upon the lever, and distance of the valve from the centre of motion given, to find what weight will be required upon the lever at that distance.*

RULE.—From the required pressure on the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the distance between the fulcrum and the weight, and the quotient is the weight in lbs. required to be placed upon the lever at that distance.

2.—*When a certain pressure upon the valve is required, the weight upon the lever and distance of valve from the centre of motion given, to find where that weight must be placed.*

RULE.—From the required weight upon the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the weight in lbs. upon the lever, and the quotient is the distance in inches from the fulcrum that the weight must be placed.

3.—*When the distance of weight, distance of valve from the centre of motion, and weight upon the lever given, to find what pressure is upon that valve.*

RULE.—Multiply the weight in lbs. upon the lever by the distance in inches to the fulcrum, divide the product by the distance between the fulcrum and the valve, and the quotient, plus the weight of the valve and effective weight of the lever, equal the weight upon the valve in lbs.

EXAMPLE 1.—Suppose the lever A B (as above) to be 24 inches in length, and the valve C placed 5

inches from the centre of motion A, what weight must be placed upon the lever 20 inches from A, to equal 80 lbs., on the valve C, the weight of the lever being 2 lbs., the weight D, which balances the lever, $4\frac{1}{2}$ lbs., and the weight of the valve 3 lbs.

2 lbs. weight of the lever.
4.5 to balance ditto.
3 weight of the valve.
9.5 lbs. then $\frac{80 - 9.5 \times 5}{20} = 17.625$ lbs.

EXAMPLE 2.—Suppose, as in the last example, the weight upon the lever equal 17.625 lbs., it is required at what distance from A the weight must be placed to equal 80 lbs. at C.

$$\frac{80 - 9.5 \times 5}{17.625} = 20 \text{ inches.}$$

EXAMPLE 3.—Suppose, as before, that a weight of 17.625 lbs. is placed upon the lever 20 inches from A, required the pressure at C, the distance from the centre of motion being 5 inches, and the effective weight of the lever at that point equal $6\frac{1}{2}$ lbs., also the weight of the valve 3 lbs.

$$\begin{aligned} \frac{17.625 \times 20}{5} &= 70.5 \\ &+ 6.5 \\ &+ 3 \\ &= 80 \text{ lbs.} \end{aligned}$$

To find the proper diameter for a safety valve.

RULE.—Multiply the bottom surface of the boiler, or surface immediately exposed to the action of the fire, in feet, by the multiplier opposite to the pressure in lbs. on each square inch of the safety valve, and the square root of the product is the valve's diameter in inches at the narrowest part. If the boiler is to have two safety

valves, then the square root of half the product equal the diameter of each.

Pressure in lbs. per square inch.	Multipliers.	Pressure in lbs. per square inch.	Multipliers.
3	.356	15	.315
4	.353	20	.305
5	.348	25	.293
6	.344	30	.289
7	.339	35	.282
8	.836	40	.275
10	.329	45	.270
12	.321	50	.264

Table of the elastic force of steam on a square inch.

Steam with a pressure of	lbs. on a square inch, equal	lbs. on a circular inch; and to maintain that pressure requires to be kept at a uniform temperature of	° F	and will support a column of mercury	inches in height.
2½	1.963		220		5.15
3	2.356		222		6.18
3½	2.749		223½		7.21
4	3.141		225½		8.24
4½	3.534		227		9.27
5	3.927		228½		10.3
5½	4.320		230		11 3
6	4.712		231½		12 3
6½	5.105		233		13.4
7	5.498		234		14.4
7½	5 890		235		15.4
8	6.283		236		16.5
8½	6.676		237½		17 5
9	7.068		239		18.5
9½	7.461		240		19 6
10	7.854		241		20.6
10½	8.247		242		21.6
11	8.639		243		22 6
11½	9.032		244		23.7
12	9.424		245½		24.7
15	11.78		252		30.9
20	15.71		261		41.2
25	19.63		269		51.5
30	23.56		276		61.8
35	27.49		283		72.1
40	31.41		289		82.4
45	35.34		294½		92 7
50	39.27		300		103

Multiply the degrees of heat in either this or the following table by .06, and the product will be the

superficial feet of flue plate exposed to the action of the fire for each horse power.

And multiply the degrees of heat by .41, and the product will be the areal inches of furnace bar for each horse power.

Table of the elastic force of steam on a circular inch.

Steam with a pressure of	lbs. on a circular inch, equal	lbs. on a square inch; and to maintain that pressure requires to be kept at a uniform temperature of	° F	and will support a column of mercury	inches in height.
2½	3.183		222½		6.56
3	3.819		224½		7 87
3½	4.456		226½		9.18
4	5.093		228½		10.5
4½	5.729		230½		11.8
5	6.366		232		13.1
5½	7.002		234		14.4
6	7.639		235½		15.7
6½	8.276		236½		17.0
7	8.912		238½		18.3
7½	9.549		239½		19.7
8	10.18		241		21.0
8½	10.82		242½		22.3
9	11.45		244		23.6
9½	12.09		245½		24 9
10	12.73		247		26 2
10½	13.36		248½		27.5
11	14.00		250		28.9
11½	14.64		251		30.1
12	15.27		252½		31.5
15	19.09		259		39.3
20	25.46		270		52.5
25	31.83		278½		65 6
30	38.19		287		78 7
35	44.56		294		91.8
40	50.92		300½		105
45	57.20		305		118
50	63.66		309		131

Proportions of fuel.

The proportion that various substances bear to each other in producing heats sufficient to raise equal quan-

tities of water to equal temperatures are nearly as follows:

Coke.....	0.375	Culm or Slack..	1.875
Coal	1.000	Wood	2.875

Hence, multiply the degrees of heat in either of the preceding tables by the following numbers opposite the material by which the steam is to be produced, and the product will be the weight in lbs. avoirdupois that is required on an average per hour for each horse power:

Coke.....	.024	Slack	.118
Coal	.063	Wood	.18

To find the height of a column of water to supply a steam boiler against any pressure of steam required.

RULE.—Multiply the pressure in pounds (upon a square inch of the boiler) by 2.5, and the product will be the height in feet above the surface of water in the boiler.

EXAMPLE.—Required the length of feed pipe capable of supplying a boiler with water when the pressure of steam is 4 pounds per square inch.

$2.5 \times 4 = 10$ feet above the surface of the water in the boiler.

STEAM ENGINE is the name of a machine which derives its moving powers from the elasticity and condensibility of steam.

Steam, to produce a maximum of useful effect as a moving power, requires to be reduced to a certain determined velocity, and although this maximum velocity has been exhibited to the public by various eminent writers upon the steam engine, still discrepancies exist amongst practical engineers; and no universally acknowledged rules have as yet been established; however, the following tables may be relied upon as exhibiting the results deduced from the most celebrated

rules, and tested by many engines doing the greatest amount of duty, as proved by accurate trials with indicators of the most recent and approved construction.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	43	172	4 6	24¼	218¼
2 6	38	190	5 0	22	220
3 0	34	204	6 0	19	228
3 6	30	210	7 0	17½	245
4 0	27	216	8 0	16	256

N.B.—These are to be considered as the velocities of land engines, or engines whose connecting rods are not less than three times the length of stroke; but marine engines, being generally confined to connecting rods of not more than 2 or 2½ times the length of stroke, have their maximum velocities considerably reduced. Hence, the subjoined table will be found pretty correct when the periphery of the wheels moves with a velocity of about 1300 feet per minute, and the floats, or paddle boards, calculated by the following rules, which I have found, in practice, to produce the greatest satisfaction, namely, economizing of fuel, a steady supply of steam, without waste, and the vessel propelled quicker than when the surface of the floats was less, and moving at a greater velocity.

Table of velocities for marine engines.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	42	168	4 0	24	192
2 3	39½	177¾	4 6	21½	193½
2 6	36	180	5 0	20	200
2 9	33	181	5 6	19	209
3 0	31	186	6 0	18	216
3 6	27	189	7 0	15¾	220½

To find the surface of the floats or paddle boards.

RULE 1.—Multiply the number of horses' power that the engine is equal to by 3.75, divide the product by the diameter of the wheel in feet, and the quotient is the area of each float, or paddle board.

RULE 2.—Multiply the area of the floats by .54, the product is the length in feet; then divide the area by the length, and the quotient is the breadth.

EXAMPLE.—Required the area, length, and breadth of each paddle board, for a steam vessel with two engines of 80-horse power each, and wheels of 20 feet diameter.

$$\frac{80 \times 3.75}{20} = 15 \text{ feet area.}$$

$15 \times .54 = 8.1$ feet the length of each board.

And $15 \div 8.1 = 1.85$, or 1 foot 10 inches in breadth.

And when there is only one engine in the vessel, $\frac{2}{3}$ of the quotient is the area of each board nearly.

Each wheel, from 12 to 14 feet diameter, ought to have 12 floats; from 14 to 16 feet diameter, 14 floats; from 16 to 18 feet diameter, 16 floats; and from 18 to 22 feet diameter, 18 floats, &c.

Principles upon which the rule is founded for calculating the power of a steam engine.

Hitherto it has been customary, in estimating the power of condensing engines, to reckon the force of the steam at a constant quantity, namely, $2\frac{1}{2}$ lbs. per circular inch, totally disregarding any extra pressure in the boiler, or increased weight upon the safety valve.

Hence, in order to form a rule whereby to approximate more nearly to the real effective power of the engine, it was necessary first to ascertain the effective force of the steam,—And,

To determine this, I recently made a series of experiments upon engines without any extra lap upon the

valves, whereby to work expansively, when I found that, on account of the nature of the valve's motion, only about three-fourths of the stroke was performed by steam at, or near, the density of the steam in the boiler, the stroke, of course, being terminated expansively; hence, the whole effective force of the steam thus applied can only be taken at about four-fifths of its original pressure.

The benefit arising from the condenser is on an average equal to 26 inches of mercury, or about 13lbs. per square inch, consequently, 13 plus four-fifths of the pressure on each square inch of the safety valve, equal the whole effective force on each square inch of the piston's area.

Then about $8\frac{1}{4}$lbs. is expended in overcoming the resistance and friction of a condensing engine, and may be thus estimated: 13 minus $8\frac{1}{4}$ equal $4\frac{3}{4}$, and $4\frac{3}{4}$ plus $\frac{4}{5}$ths of the weight upon each square inch of the safety valve equal the whole amount of useful effect in giving motion to machinery.

The process of calculation may be simplified thus: $4\frac{3}{4}$lbs. per square inch = 3.73 lbs. per circular inch, by which means the circle only requires to be squared, and the labour of multiplying by .7854 is dispensed with.

GENERAL RULES.

1.—Multiply the square of the cylinder's diameter in inches by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient is the effect of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder $24\frac{1}{2}$ inches diameter, stroke 4 feet, or 200 feet velocity per minute, and the

weight upon the safety valve 3.5 lbs. per circular inch, required the effective power.

$\frac{4}{5}$ths of 3.5 = 2.8, and 3.73 + 2.8 = 6.53 lbs. effective force.

Then $\frac{24.5^3 \times 6.53 \times 200}{33000} = 24$ horses' power.

2.—Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder for an engine of 30 horses' power, with a 6 feet stroke, or 228 feet per minute, and steam at $2\frac{1}{2}$ lbs. per circular inch.

$\frac{4}{5}$ths of 2.5=2; and 3.73 + 2=5.73 lbs. effective force.

Hence, $\frac{33000 \times 30}{228 \times 5.73} = \sqrt{758} = 27\frac{1}{2}$ inches diameter.

NOTE.—To obtain four-fifths of the pressure of steam, multiply the original pressure by 4 and divide by 5, the quotient is the pressure required.

The above are to be taken as general practical rules for engines not working expansively further than what is compulsory from the nature of the slide valve; but where engines are worked more expansively, and greater accuracy required, recourse must be had to the following rules for obtaining the uniform force of the steam.

RULE 1.—Divide the length of the stroke in inches by the distance (also in inches) that the piston moves before the steam is shut off, and divide the pressure on the boiler in lbs. by the quotient :—

2.—Add 1 to the hyperbolic logarithm of the number of times to which the steam is expanded, and multiply the logarithm by the number of lbs. to which the steam is expanded, and the product is the uniform force of the steam acting throughout the whole stroke.

EXAMPLE.—Let the steam in the boiler of an engine equal 45 lbs. per inch, the length of stroke 4 feet, and the steam to be shut off after the piston has moved 16 inches; required an equivalent force of steam in the cylinder.

4 feet = 48 inches, and 48 ÷ 16 = 3.
Then, 45 ÷ 3 = 15 lbs. And, 1 + 1.0986123 = 2.0986123 × 15 = 31.4791845 lbs. uniform force of the steam.

HYPERBOLIC LOGARITHMS.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1¼	.2231435	3¼	1.1786549	5¼	1.6582280	7¼	1.9810014
1½	.4054651	3½	1.2527629	5½	1.7047481	7½	2.0149030
1¾	.5596157	3¾	1.3217558	5¾	1.7491998	7¾	2.0476928
2	.6931472	4	1.3862943	6	1.7917594	8	2.0794415
2¼	.8109302	4¼	1.4469189	6¼	1.8325814	8½	2.1400661
2½	.9162907	4½	1.5040774	6½	1.8718021	9	2.1972245
2¾	1.0116008	4¾	1.5581446	6¾	1.9095425	9½	2.2512917
3	1.0986123	5	1.6094379	7	1.9459101	10	2.3025851

THE STEAM WAY.

Multiply any cylinder's area by .034, and the product will be the area of port or steam way.

EXAMPLE.—What area of port or steam way is necessary for a cylinder 36 inches diameter?

36 inches diameter = 1017.8 inches area × .034 = 34.6 inches area of steam way.

OF THE SLIDE VALVE.

When the valve is at the middle of its stroke, the faces ought to cover the apertures on the exhausting side about $\frac{1}{10}$ of an inch; the cover on the steam side being for the purpose of cutting off the steam at any part of the stroke, is, therefore, at the entire discretionary judgment of the engineer. However, we find from practice, that high-pressure engines with short strokes, as locomotives, &c., require no more than will cover the apertures properly; whereas condensing engines, with steam of $2\frac{1}{2}$ to 3 lbs. per square inch, will work well with $\frac{5}{8}$ of an inch cover on the steam side; and marine engines give great satisfaction with $1\frac{1}{8}$ inches cover, when the steam is $4\frac{1}{2}$ lbs. to 5 lbs. per square inch.

Again, the lead of the valve (as it is termed amongst engineers) is a certain distance that the extremity of the eccentric must be in advance of the crank, so that the valve may be open as required when the piston is at the top or bottom of the cylinder,—for this reason, that, at the return of the stroke, the steam in the cylinder may be of, or nearly, an equal density with the steam in the boiler; consequently, the nearer that the length of the aperture is to the area of the cylinder, the less lead is required. Thus,

Suppose a cylinder of 48 inches diameter, with an aperture 16 inches long, $\frac{48^2}{16} = 144$; and another 24 inches diameter, with an aperture 8 inches long, $\frac{24^2}{8} = 72$; then $\frac{144}{72} = 2$. Hence it is evident that, although both apertures bear the same proportion to the diameter of the cylinder, and both valves move the same distance, the 48 inch cylinder would be twice the time in filling with steam to that of the 24 inch, for a cylinder twice the diameter is four times the area; but scarcely two engineers agree upon this point. However, the following is an approximate rule to a number

of celebrated working engines, namely: Multiply the square of the cylinder's diameter in inches by .002, and divide the product by the length of the aperture, also in inches; the quotient will be the width that the valve must be open when the piston is exactly at the top or bottom of the cylinder.

EXAMPLE.—Let a cylinder be 30 inches diameter, with an aperture 12 inches long.

$$\frac{30^2 \times .002}{12} = .15$$ parts of an inch for the aperture to be open at the return of the stroke.

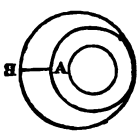
THE ECCENTRIC.

1.—The length of the levers on the weigh or traverse shaft given, to find the required throw of the eccentric.

RULE.—Multiply the distance that the valve is to travel by the length of the lever on the weigh shaft for the eccentric rod; divide the product by the length of the lever for working the valve, and the quotient is the throw of the eccentric.

EXAMPLE.—Let a valve be required to travel 6 inches, the lever on the weigh shaft for working the valve 12 inches in length, and the lever for the eccentric rod 10 inches; required the throw of that eccentric.

$$\frac{6 \times 10}{12} = 5$$ inches throw.



The throw of the eccentric is the distance between A and B on that eccentric.

2.—The throw of the eccentric and the stroke of the valve, also one of the levers on the weigh shaft given, to find the other.

RULE.—Multiply the throw of the eccentric by the length of the lever to work the valve, and divide by the distance the valve is to travel; the quotient will be the length of the other lever. Or,

Multiply the travel of the valve by the length of the lever on the weigh shaft, for the eccentric rod, and divide by the throw of the eccentric; the quotient will be the length of the lever for working the valve.

EXAMPLE.—Suppose a valve be required to travel 6 inches, the throw of the eccentric 5, and the length of the lever on the weigh shaft for working equal 12 inches; required the length of the other.

$$\frac{5 \times 12}{6} = 10 \text{ inches; or}$$

$$\frac{6 \times 10}{5} = 12 \text{ inches.}$$

THE COLD WATER PUMP.

Taking practice as a data whereby to determine the quantity of water sufficient for condensation in all ordinary cases of the steam engine, I find that, at the common temperature of the atmosphere, four imperial gallons of water to each horse power are quite capable of condensing steam at 220° Faht. to water at 80°; but if the temperature of the steam be raised, the quantity of water must be augmented, according to the result of the following

RULE.—Multiply the temperature of the steam in the boiler by .019, and the product will be the quantity required in imperial gallons per minute to each horse power. Hence, to find the diameter of the pump, when the stroke is given, or the stroke of the pump, when the diameter is given,

Multiply the quantity required in gallons for each horse power by the number of horses' power that the engine is equal to, and by 353; divide the product by the intended stroke of the pump in inches multiplied by the number of strokes per minute, and the square root of the quotient is the pump's diameter in inches.

Or, divide the product by the number of strokes per minute multiplied by the square of the pump's diameter, and the quotient is the length of the stroke.

EXAMPLE.—Let an engine of 25 horses' power be propelled by steam at 7 lbs. per square inch, what must be the pump's diameter when the stroke is 23 inches, and making 22 strokes per minute?

7 lbs. per square inch = 234°; and
234 × .019=4.446 gallons to each horse power.

Then $\frac{4.446 \times 25 \times 353}{23 \times 22} = \sqrt{77.54} = 8.8$ inches diameter nearly.

Or, $\frac{4.446 \times 25 \times 353}{77.54 \times 22} = 23$ inches length of stroke.

NOTE.—The diameter of the injection cock ought to be at least equal to $\frac{1}{12}$th of the cylinder's diameter.

To find the necessary quantity of water for a boiler.

RULE.—Add 15 to the pressure on each square inch of the boiler in lbs., divide the sum by 18, multiply the quotient by .2, and the product is the quantity in imperial gallons per minute for each horse power. Hence, the rule for the cold water pump is also applicable for the hot water pump.

EXAMPLE.—Suppose a 6-horse engine to be propelled by steam at 30 lbs. per square inch, stroke of pump 9 inches, and making 45 strokes per minute, required the pump's diameter.

$\frac{30 + 15}{18} = 2.5 \times .2 = .5$ of a gallon per minute to each horse power.

Then $\frac{.5 \times 6 \times 353}{45 \times 9} = \sqrt{2.6} = 1.6$ inches diameter, nearly.

Or, $\frac{.5 \times 6 \times 353}{45 \times 2.6} = 9$ inches length of stroke.

THE AIR PUMP.

The *Air Pump* for a land engine generally requires to be larger in proportion to the cylinder than the air pump for a marine engine, on account of having frequently to condense with water at a higher temperature; hence, when the stroke of the bucket is half the stroke of the piston, multiply the cylinder's diameter in inches by .67, and the product is the diameter of air pump.—Again, multiply the diameter of the cylinder of a marine engine, in inches, by .575, and the product is the diameter of air pump.

EXAMPLE.—What diameter of air pump is requisite for an engine whose cylinder is 28 inches diameter?

$28 \times .67 = 18.76$ inches diameter.

When the stroke of the bucket is either more or less than half the stroke of the piston, the pump's diameter will then be obtained by the following

RULE.—Square the given diameter, multiply by the length, and divide by the length proposed, extract the square root, and the product will be the diameter.

EXAMPLE.—Suppose an engine with a 4 feet stroke required an air pump 26 inches diameter with a 2 feet stroke, but necessity requires it to be 6 inches nearer the end of the beam, what must be the diameter of air pump, the beam being 11 feet long?

Radius of beam = 66 inches. Then,

As 66 : 48 :: 39 : 28.36 inches, length of stroke;

And $\sqrt{\frac{26^2 \times 24}{28.36}} = 24$ inches, diameter of pump nearly.

The *Condenser* ought to be a little more in capacity than the air pump; but in the case of marine engines, where the bottom of the condenser and bottom of the cylinder are nearly on a level, care must be taken to make the passage between the valves and condenser large enough to contain the condensing water required

for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and condenser will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

The area of air pump multiplied by .25 will give the area of foot and discharging valves; thus, 24 inches diameter = 452.39 inches area, × .25 = 113.0975 inches, area of valves.

The piston rod is about $\frac{1}{10}$ of the cylinder's diameter; the air pump rod in the same proportion, unless it be made of copper, and then it may be about $\frac{1}{8}$ of the pump's diameter.

THE BEAM.

When a beam is applied to an engine its length ought not to be less than three times the length of the stroke, and its breadth half the stroke, or in high pressure engines $\frac{2}{5}$ of the stroke; also its best form is a parabola.

To find the thickness of a beam, when the length, breadth, and diameter of the cylinder are given.

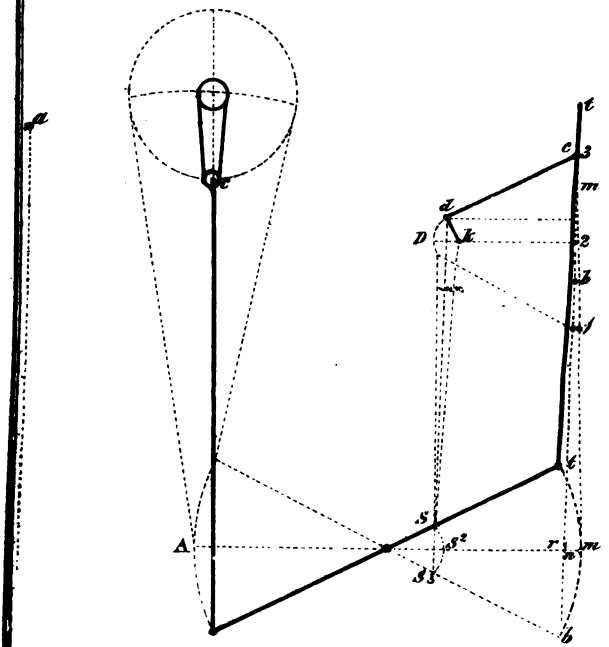
RULE.—Multiply the whole pressure of steam on the piston in lbs. by half the length of the beam in feet, and divide the product by 70 times the square of the breadth in inches, and the quotient will be the thickness in inches nearly.

EXAMPLE.—What thickness of beam is requisite for an engine whose cylinder is 25 inches diameter, the length of the beam being 15 feet, length of stroke 5 feet, and the effective pressure on each square inch of the piston equal 15 lbs.

Area of piston = 490.875 inches.

And $\frac{490.875 \times 15 \times 7.5}{30^2 \times 70}$ = .876 or $\frac{7}{8}$ of an inch in thickness nearly.

FIG 3rd A motion that is chiefly used in marine Engines.



To find the versed sine of the arc described by the beam of an engine.

RULE.—Divide the square of half the length of the stroke in inches, by the length of the beam also in inches, and the quotient is the versed sine.

EXAMPLE.—Required the versed sine of the arc described by an engine beam 12 feet in length, the chord of the arc or length of the stroke being 4 feet.

$$\frac{24^2}{144} = 4 \text{ inches the versed sine.}$$

NOTE.—When the beam is not equal lengths at each end from the centre on which it vibrates, the length is then to be taken equal to twice the radius of that end of which the versed sine is required.

THE PARALLEL MOTION.

The beam being given, to find the length of the radius rods.

RULE.—Divide the square of the distance between A and B, on the beam, by the distance between B and C, and the quotient is the length of the radius rod $d\ x$.

FIG. 1, EXAMPLE.—Suppose a beam 12 feet long, and the stud for the back links 39 inches from the centre, required the length of radius rods.

Radius of beam = 72 inches, and $72 - 39 = 33$

then $\frac{39^2}{33} = 46.09$ inches.

NOTE.—The length of the front and back links equal half the length of the stroke.

FIG. 2, EXAMPLE.—Suppose $b\ d = 32\frac{1}{4}$, and $d\ a = 35\frac{1}{4}$, to find d F.

$$\frac{32.25^2}{35.25} = 29.5 \text{ inches nearly.}$$

FIG. 3.—As the calculation of this motion is rather tedious, on account of the various angles formed by the

side rods, it is considered better to lay it down in the following geometrical form :—

Upon the line A *m*, with the radius of the beam, describe the arc *b m t;* from *m*, with half the length of stroke, cut the arc in *b* and *t*, draw the line *b t* and *r m* equal the versed sine described by the beam; bisect *r m* in *n*, and erect a perpendicular line for the centre of the cylinder. Again, from *b m t*, with the length of the side rods, cut the perpendicular line; at the bottom, middle, and top stroke of the cross-head draw the lines *b b*, *m m*, *t t;* from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance *s t*, describe arcs at *d* D *d;* draw the lines *d* 1, D 2, &c. Then the length of the crank may be found either by the sixth problem in Geometry, or the eighth problem in Mensuration.

THE CONNECTING ROD.

The proportionate length of connecting rod is three times the length of stroke, which determines the perpendicular distance between the centre of the beam and centre of fly-wheel shaft. Or, if the engine is erected, the length of connecting rod is the perpendicular distance between the centre of the fly-wheel shaft and centre of the beam.

THE FLY WHEEL.

To find the weight of the rim or ring of a fly-wheel proper for a steam engine.

RULE.—Multiply the constant number, 1368, by the number of horses' power that the engine is equal to; divide the product by the diameter of the wheel, in feet, multiplied by the number of revolutions per minute; and the quotient is the weight of the ring in cwts. nearly.

EXAMPLE.—Required the weight of the rim of a fly-wheel proper for an engine of 20 horses' power, the

wheel to be 16 feet diameter, and make 21 revolutions per minute.

$$\frac{1368 \times 20}{16 \times 21} = 81.4 \text{ cwt. nearly.}$$

NOTE.—The fly-wheel of an engine for a corn or flour mill ought to be of such a diameter that the velocity of the periphery of the wheel may exceed the velocity of the periphery of the stones, to prevent, as much as possible, any tendency to back lash, as it is termed.

The necessary weight and diameter of the wheel being found, suppose a breadth of rim, and the thickness to make the weight in cast iron will be found by the following

RULE.—Divide the required weight in lbs. by the area of the ring in inches, multiplied by .263, and the quotient is the thickness of the ring in inches.

EXAMPLE.—What thickness must a ring be to equal 81.4 cwts. when the outer diameter is 16 feet, and the inner diameter 14 feet 8 inches?

81.4 cwts. = 9116.8 lbs.

And, by Problem XII in Mensuration, the area of the ring = 4624.43 inches.

Then, $\frac{9116.8}{4624.43 \times 263} = 7.496$ inches nearly.

And if the ring is to be of a cylindrical form, find the diameter of a circle, (by Problem IX in Mensuration,) having the same area as the cross-section of the ring found.

Thus, suppose the ring, in the last example, be required to be cylindrical,—Required its cross-sectional diameter to equal 81.4 cwts., the diameter of the wheel being 16 feet.

$7.496 \times 8 = 59.968$ inches cross-sectional area of the ring found.

And $\sqrt{\frac{59.968 \times 452}{355}} = 8.73$ inches diameter nearly.

Or, as an approximate, multiply the required weight in lbs., by 1.62; divide the product by the diameter of the wheel, in inches, and the square root of the quotient will be the diameter of the cross-section of the ring, in inches, nearly.

Thus, $\sqrt{\frac{9116.8 \times 1.62}{16 \times 12}} = 8.77$ inches.

Sometimes (for various reasons) it is necessary to have the fly-wheel upon a second mover; for instance, there is a 6-horse engine making 50 revolutions per minute, having a fly-wheel of 7 ft. diameter, and 9 cwt., but, by the rule, it ought to be 23.46 cwt. Now, a larger wheel cannot be got in, but the same may be put upon a second motion,—required the velocity that will increase its momentum equal to 23.46 cwt. on the first motion.

7 feet diameter = 21.9912 feet circumference, and 21.9912 × 50 revolutions = 1099.56 feet velocity.

Cwt. Velocity. Cwt. Velocity.

Then, as 9 : 1099.56 :: 23.46 : 2866.1864 ÷ 21.9912 = 130 revolutions per minute nearly.

To find the centrifugal force of a fly-wheel.

RULE.—Multiply the decimal .6136 by the diameter of the wheel in feet, and divide the product by the square of the time of one revolution; the quotient will be the centrifugal force when the weight of the body is 1.

EXAMPLE.—Required the centrifugal force of a fly-wheel 15 feet diameter, and making 40 revolutions per minute, the weight of the ring being 3 tons,

60 ÷ 40 = 1.5, time of one revolution.

And $\frac{.6136 \times 15}{1.5^2} = 4.09 \times 3 = 12.27$ tons, the centrifugal force.

The centre of percussion in a fly-wheel, or wheels in general, is $\frac{1}{3}$ distant from the centre of suspension nearly.

NOTE.—The centrifugal force is that power or tendency which all revolving bodies have to burst, or fly asunder in a direct line.

And the centre of percussion in a revolving body is that point where the whole force or motion is collected, or that point which would strike any obstacle with the greatest effect.

THE GOVERNOR OR REGULATOR.

The length of pendulums given, to find the number of revolutions per minute.

RULE.—Divide 375 by the square root of the pendulum's length, and half the quotient will be the velocity required.

EXAMPLE.—What number of revolutions ought a governor to make per minute whose pendulums are 24 inches long?

$$\frac{375}{\sqrt{24}} = 76 \div 2 = 38 \text{ revolutions per minute.}$$

The revolutions per minute of a governor given, to find the length of pendulums.

RULE.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient will be the length required.

EXAMPLE.—When the velocity of a governor is 38 revolutions per minute, what ought to be the length of pendulums?

$38 \times 2 = 76$, and $\frac{375}{76} = 4.93^2 = 24.3049$ inches nearly.

OF HIGH PRESSURE ENGINES.

High pressure engines, in general, (if in good condition,) will work when the force of the steam is about 4 lbs. per circular inch,—that is, 4 lbs. on each circular inch of the piston will overcome the resistance and friction of the engine itself, divested of machinery, &c. Hence the rule.

1. From the pressure in lbs. on each circular inch of the boiler deduct 4 lbs.; multiply the remainder by the square of the cylinder's diameter in inches, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient will be the force of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder 8 inches diameter, stroke 2 feet, making 45 revolutions per minute, or 180 feet, and steam 23.5 lbs. per circular inch, required the power.

$$23.5 - 4 = \frac{19.5 \times 8^2 \times 180}{33000} = 6.8 \text{ horses'}$$

power nearly.

2. Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiply by the force of the steam in lbs. on each circular inch of the boiler, minus 4 lbs., and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of the cylinder for an engine of 6.8 horses' power, when the stroke is 2 feet, and making 45 strokes per minute, the force of the steam being 23.5 lbs. per circular inch.

$$\frac{33000 \times 6.8}{180 \times 23.5 - 4} = \sqrt{64} = 8 \text{ inches diameter.}$$

NOTE.—There is always a resistance of steam on the piston of a high-pressure or non-condensing engine equal to the pressure of the atmosphere, but this cannot be taken into account, unless we also take into account the pressure of the *atmosphere upon* the boiler.

MISCELLANIES.

Approximate rules for finding the weight of round, square, and rectangular beams, bars, &c., of cast and wrought iron.

RULE 1.—Multiply the square of the diameter in inches by the length in feet, and by 2.6 for wrought iron, or 2.48 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

2.—Multiply the area of the cross section in inches by the length in feet, and by 3.32 for wrought iron, or 3.16 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

EXAMPLE 1.—Required the weight of a round bar of wrought iron 14 feet long and $2\frac{1}{2}$ inches diameter.

$$2.5^2 \times 14 = 87.50 \times 2.6 = 227.5 \text{ lbs.}$$

EXAMPLE 2.—The length of a piece of cast iron is $9\frac{1}{2}$ feet, its breadth 7 inches, and thickness $2\frac{1}{4}$, required its weight.

$$2.25 \times 7 = 15.75 \times 9.5 = 149.625 \times 3.16 = 472.815 \text{ lbs.}$$

The dimensions of a cast iron ring being given, to find its weight nearly.

RULE.—Multiply the breadth of the ring added to the inner diameter by .0074, and that again by the breadth and by the thickness, and the product will be its weight in cwts. nearly.

EXAMPLE.—Required the weight of a ring whose dimensions are 8 feet 4 inches, interior diameter 5 inches broad and 4 inches thick.

$$\text{8 feet 4 inches} = \overset{\text{Inches.}}{100} + 5 = 105 \times .0074 = .777 \times 5 = 3.885 \times 4 = 15.52 \text{ cwts. nearly.}$$

To find the weight of any cast iron ball whose diameter is given.

RULE.—Multiply the cube of the diameter in inches by .1377, and the product will be the weight in avoirdupois pounds nearly.

EXAMPLE.—Required the weight of a ball 7 inches diameter.

$$7^3 = 343 \times .1377 = 47.2211 \text{ lbs.}$$

To find the diameter of a cast iron ball when the weight is given.

RULE.—Multiply the cube root of the weight in pounds by 1.936, and the product will be the diameter in inches nearly.

EXAMPLE.—Required the diameter of a ball that will weigh 64 pounds.

$$\sqrt[3]{64} = 4 \times 1.936 = 7.744 \text{ inches diameter.}$$

TABLE

Containing the weight of a square foot of copper and lead, in lbs. avoirdupois, from $\frac{1}{32}$ to $\frac{1}{8}$ an inch in thickness, advancing by $\frac{1}{32}$.

Thickness.	Copper.	Lead.
$\frac{1}{32}$	1.45	1.85
$\frac{1}{16}$	2.90	3.70
$\frac{3}{32}$	4.35	5 54
$\frac{1}{8}$	5.80	7.39
$\frac{1}{8}$ & $\frac{1}{32}$	7.26	9.24
$\frac{1}{8}$ & $\frac{1}{16}$	8.71	11.08
$\frac{1}{8}$ & $\frac{3}{32}$	10.16	12 93
$\frac{1}{4}$	11.61	14.77
$\frac{1}{4}$ & $\frac{1}{32}$	13.07	16.62
$\frac{1}{4}$ & $\frac{1}{16}$	14.52	18.47
$\frac{1}{4}$ & $\frac{3}{32}$	15.97	20.31
$\frac{2}{8}$	17.41	22.16
$\frac{2}{8}$ & $\frac{1}{32}$	18.87	24.00
$\frac{2}{8}$ & $\frac{1}{16}$	20.32	25.85
$\frac{2}{8}$ & $\frac{3}{32}$	21.77	27.70
$\frac{1}{2}$	23.22	29.55

TABLE

Of the weight of a square foot of sheet iron in lbs. avoirdupois, the thickness being the number on the wire gauge.—No. 1 is 5/16 of an inch; No. 4, 1/4; No. 11, 1/8, &c.

No. on wire gauge	1	2	3	4	5	6	7	8	9	10	11
Pounds avoir.....	12.5	12	11	10	9	8	7.5	7	6	5.68	5
No. on wire gauge	12	13	14	15	16	17	18	19	20	21	22
Pounds avoir.....	4.62	4.31	4	3.95	3	2.5	2.18	1.93	1.62	1.5	1.37

TABLE

Of the weight of a square foot of boiler plate iron, from 1/8 to 1 inch thick, in lbs. avoirdupois.

1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in
5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40

TABLE

Of the weight of solid cylinders of cast iron, 12 inches long, in lbs. avoirdupois.

Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.
1/8	1.394	2 1/8	11.193	3 1/8	30.364	5 1/4	81.952	9	200.774
1/4	1.897	2 1/4	12.548	3 1/4	32.572	6	89.234	9 1/2	223.704
3/8	2.478	2 3/8	13.981	3 3/8	34.857	6 1/4	96.825	10	247.872
1 in.	3.137	2 1/2	15.492	3 1/2	37.219	6 1/2	104.726	10 1/2	273.278
1 1/8	3.873	2 5/8	17.080	4	39.660	6 3/4	112.936	11	299.925
1 1/4	4.686	2 3/4	18.745	4 1/4	44.771	7	121.457	11 1/2	327.811
1 3/8	5.577	2 7/8	20.488	4 1/2	50.193	7 1/4	130.287	12	356.935
1 1/2	6.545	3	22.308	4 3/4	55.926	7 1/2	139.428	13	418.903
1 3/4	7.591	3 1/8	24.206	5	61.968	7 3/4	148.878	14	485.830
1 7/8	8.714	3 1/4	26.181	5 1/4	68.319	8	158.638	15	557.712
2	9.915	3 3/8	28.234	5 1/2	74.981	8 1/2	179.087	16	634.552

Cubic inches of cast iron multiplied by .263 = lbs. avoirdupois.

Circular inches of cast iron multiplied by .2065 = lbs. avoirdupois.

TABLE

For finding the weight of malleable iron, copper, and lead pipes, 12 inches long, of various thicknesses, and any diameter required.

Thickness.	Mall. Iron.	Copper.	Lead.
1/32 of an inch.	.104	.121	.1539
1/16	.208	.2419	.3078
3/32	.3108	.3628	.4616
1/8	.414	.4838	.6155
1/8 & 1/32	.518	.6047	.7694
1/8 & 1/16	.621	.7258	.9232
1/8 & 9/32	.725	.8466	1.0771
1/4	.828	.9678	1.231

RULE.—Multiply the circumference of the pipe in inches by the numbers opposite the thickness required, and by the length in feet; the product will be the weight in avoirdupois lbs. nearly.

EXAMPLE.—Required the weight of a copper pipe 12 feet long, 15 inches in circumference, 1/4 and 1/32 of an inch in thickness.

.7258 × 15 = 10.887 × 12 = 130.644 lbs. nearly.

TABLE

Containing the weight of wrought iron bars 12 *inches long in lbs. avoirdupois.*

Inch.	Round.	Square.	Inch.	Round.	Square.
1/16	.163	.208	2 1/8	16.32	20.80
1/8	.367	.467	2 2/8	18.00	22.89
3/16	.653	.830	2 3/8	19.76	25.12
4/16	1.02	1.30	2 4/8	21.59	27.46
5/16	1.47	1.87	3	23.52	29.92
6/16	2.00	2.55	3 1/4	27.60	35.12
1	2.61	3 32	3 2/4	32.00	40.80
1 1/16	3.31	4.21	3 3/4	36.72	46.72
1 2/16	4.08	5 20	4	41.76	53 12
1 3/16	4.94	6.28	4 1/4	47.25	60.00
1 4/16	5.88	7.48	4 2/4	52.93	67.24
1 5/16	6.90	8.78	4 3/4	58.92	74.95
1 6/16	8.00	10.20	5	65 28	83.20
1 7/16	9.18	11.68	5 1/4	72.00	91.56
2	10.44	13.28	5 2/4	79.04	100 48
2 1/8	11.80	15.00	5 3/4	86.36	109.82
2 2/8	13.23	16.81	6	94.08	119.68
2 3/8	14.73	18.74	7	128.00	163 20

TABLE

Of the proportional dimensions of 6 *sided nuts for bolts, from* 1/4 *to* 2 1/4 *inches diameter.*

Diameter of bolts...	1/4	2/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Breadth of nuts.....	4/16	4/8	1	1 5/16	1 3/8	1 5/16	1 3/4	1 1/16	2 1/8
Breadth over the angles	3/4	1 2/8	1 1/8	1 3/8	1 5/8	1 1/16	2	2 1/4	2 5/16
Thickness	5/16	7/16	9/16	3/4	7/8	1	1 1/8	1 1/4	1 5/16
Diameter of bolts...	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	
Breadth of nuts.....	2 5/16	2 1/8	2 1/16	2 2/8	3 1/16	3 1/4	3 3/8	4	
Breadth over the angles	2 1/16	2 7/8	3 1/8	3 5/16	3 1/2	3 3/4	4 5/16	4 5/8	
Thickness	1 9/16	1 1/16	1 1/16	2	2 1/8	2 1/4	2 1/2	2 3/4	

TABLE

Of the weight of flat bar iron, 12 inches long, in lbs. avoirdupois.

Thickness.		1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1 inch.
Breadth in inches.	1/4	.21	.31	.42	.63					
	3/8	.31	.47	.63	.94	1.26	1.57			
	1	.42	.63	.84	1.26	1.68	2.10	2 52	2 94	
	1 1/4	.52	.78	1.05	1.57	2.10	2 62	3.15	3.67	4 20
	1 3/8	.57	.86	1.18	1 73	2 31	2 88	3.46	4 04	4.62
	1 1/2	.63	.94	1.26	1 89	2.52	3.15	3.78	4 41	5 04
	1 3/4	.73	1.10	1.47	2 20	2 94	3.67	4.41	5.14	5 87
	2	.84	1.26	1.68	2.52	3 36	4.20	5 06	5 88	6.72
	2 1/4	.96	1.41	1 89	2.83	3 78	4.72	5 66	6 61	7.56
	2 1/2	1 05	1.57	2.10	3.15	4 20	5.25	6 30	7.35	8.40
	2 3/4	1.15	1.73	2 31	3.46	4.62	5.77	6.93	8 08	9.24
	3	1.26	1 89	2.52	3 78	5 04	6.30	7 56	8 82	10.08
	3 1/4	1.36	2.04	2 73	4.09	5.46	6.82	8 19	9 55	10.92
	3 1/2	1.47	2.20	2 94	4.41	5 88	7.35	8 82	10.29	11.76
	3 3/4	1.57	2 36	3.15	4 72	6.30	7 87	9 45	11.02	12 60
	4	1.68	2 52	3.36	5.04	6 72	8.40	10 08	11 76	13.44
	4 1/2	1 89	2 83	3 73	5.67	7.56	9.45	11.34	13 23	15.12
	5	2.10	3.15	4 12	6 30	8.40	10 50	12 60	16.70	17.80
	6	2.52	3.78	5.04	7.56	10.08	12.60	15.12	17.64	20.16

Weight of a copper rod 12 inches long and 1 inch diameter = 3.039 lbs.

Weight of a brass rod 12 inches long and 1 inch diameter = 2.86 lbs.

TABLE

Of the specific gravity of water at different temperatures, that at 62° being taken as unity.

70°F.	.99913	52°F.	1 00076
68	.99936	50	1.00087
66	.99958	48	1.00095
64	.99980	46	1.00102
62	1.	44	1.00107
58	1.00035	42	1.00111
56	1.00050	40	1.00113
54	1.00064	38	1.00115

The difference of temperatures between 62° and 92° where water attains its greatest density, will vary the bulk of a gallon rather less than the third *of a cubic inch.*

TABLE

Of the weight of cast iron pipes 12 *inches long, in lbs. avoirdupois.*

Diam. of bore in inches.	THICKNESS IN INCHES.							
	⅜	½	⅝	¾	⅞	1 *in.*	1⅛	1¼
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1½	6.9	9.9	.....	.....	.....	.....	.....	.....
2	8.8	12.3	16.1	20.3	.....	.....	.....	.....
2½	10.6	14.7	19.2	23.9	.....	.....	.....	.....
3	12.4	17.2	22.2	27.6	33.3	39.3	45.6	.....
3½	14.2	19.6	25.3	31.3	37.6	44.2	51.1	.....
4	16.1	22.1	28.4	35.0	41.9	49.1	56.6	64.4
4½	18.0	24.5	31.4	38.7	46.2	54.0	62.1	70.6
5	19.8	27.0	34.5	42.3	50.5	58.9	67.6	76.7
5½	21.6	29.5	37.6	46.0	54.8	63.8	73.2	82.8
6	23.5	31.9	40.7	49.7	59.1	68.7	78.7	88.8
6½	25.3	34.4	43.7	53.4	63.4	73.4	84.2	95.1
7	27.2	36.8	46.8	56.8	67.7	78.5	89.7	101.2
7½	29.0	39.1	49.9	60.7	72.0	83.5	95.3	107.4
8	30.8	41.7	52.9	64.4	76.2	88.4	100.8	113.5
8½	32.9	44.4	56.2	68.3	80.8	93.5	106.5	119.9
9	34.5	46.6	59.1	71.8	84.8	98.2	111.8	125.8
9½	36.3	49.1	62.1	75.5	89.1	103.1	117.4	131.9
10	38.2	51.5	65.2	79.2	93.4	108.0	122.8	138.1
10½	.....	54.0	68.2	82.8	97.7	112.9	128.4	144.2
11	.....	56.4	71.3	86.5	102.0	117.8	133.9	150.3
11½	.....	58.9	74.3	90.1	106.3	122.7	139.4	156.4
12	.....	61.3	77.4	93.6	110.6	127.6	145.0	162.6
13	.....	.....	82.7	101.2	118.2	137.4	154.1	173.5
14	.....	.....	89.3	108.2	126.5	146.2	165.3	185.2
15	.....	.....	95.2	115.7	135.3	156.2	176.2	198.1
16	.....	.....	.....	123.3	143.1	166.1	187.5	211.3
17	.....	.....	.....	130.2	152.5	178.5	198.2	223.4
18	.....	.....	.....	137.0	161.2	185.3	209.1	235.6
19	.....	.....	.....	.....	169.2	195.7	222.3	247.1
20	.....	.....	.....	.....	178.1	205.2	233.2	259.0
21	.....	.....	.....	.....	.....	214.1	243.5	273.2
22	.....	.....	.....	.....	.....	223.0	254.8	285.4
23	.....	.....	.....	.....	.....	233.4	265.5	298.3
24	.....	.....	.....	.....	.....	245.2	277.5	310.6

NOTE.—The first column is the width of the pipes, expressed in inches and parts of an inch; and the remaining columns are the weights of the pipes, under the different thicknesses in which they are placed.

N.B.—Two flanges are generally reckoned equal to one foot of pipe.

TABLE

Of the weight of cast iron balls in pounds avoirdupois, from 1 *to* 12 *inches diameter, and advancing by an eighth.*

Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.
1	.14	4⅜	14.76	8⅛	84.56
1⅛	.20	4½	15.95	8¼	88.34
1¼	.27	4⅝	17.12	8⅜	92.24
1⅜	.37	4¾	18.54	8½	96.26
1½	.47	4⅞	19.93	9	160.39
1⅝	.59	5	21 39	9⅛	104.62
1¾	.74	5⅛	22.91	9¼	108.98
1⅞	.91	5¼	24.51	9⅜	113.46
2	1.10	5⅜	26.18	9½	118 06
2⅛	1.32	5½	27.91	9⅝	122.77
2¼	1.57	5⅝	29.72	9¾	127.63
2⅜	1.84	5¾	31.64	9⅞	132.60
2½	2.15	5⅞	33.62	10	137.71
2⅝	2.49	6	35.67	10⅛	142.91
2¾	2.86	6⅛	37.80	10¼	148.28
2⅞	3.27	6¼	40.10	10⅜	153.78
3	3.72	6⅜	42.35	10½	159.40
3⅛	4.20	6½	44.74	10⅝	165.16
3¼	4.72	6⅝	47.21	10¾	171.05
3⅜	5.29	6¾	49.79	10⅞	177.10
3½	5.80	6⅞	52.47	11	183.29
3⅝	6.56	7	55.23	11⅛	189.60
3¾	7.26	7⅛	58.06	11¼	196.10
3⅞	8.01	7¼	60.04	11⅜	202.67
4	8.81	7⅜	64.09	11½	209.43
4⅛	9.67	7½	67.25	11⅝	216.32
4¼	10.57	7⅝	70.49	11¾	223.40
4⅜	11.53	7¾	73.85	11⅞	230.57
4½	12.55	7⅞	77.32	12	237.94
4⅝	13.62	8	80.88		

TABLE

Of the weight of a square foot of millboard in lbs. avoirdupois.

Thickness in inches.....	⅛	3/16	¼	5/16	⅜
Weight in lbs.....	.688	1.032	1.376	1.72	2.064

TABLE

Containing some of the properties of various bodies.

Names of Bodies.	Melting and boiling points.	Contracts in cooling in parts of an inch, for each foot in length.	Expands in heating from 32 to 212 deg. of Fahrenheit the length being 1.00000.	Power of conducting heat.
Cast iron melts...	17977°	.124	.00111	1.2
Wrought iron welding hot.	12780	.137	.00122	1.1
Copper melts	4587	.193	.00172	1.0
Brass melts	3807	.210	.00187	1.0
Steel red hot.....	1077	.133	.00118	
Zinc melts.....	700	.329	.00294	
Mercury boils ...	660		.01851	
Lead melts	594	.319	.00286	2.5
Bismuth melts...	476	.156	.00139	
Tin melts	442	.278	.00248	1.7
Water boils	212		.04002	

TABLE

Showing the expansion of water by heat.

Temperature.	Expansion.	Temperature.	Expansion.
12°F.	1.00236	122°F.	1.01116
22	1.00690	132	1.01367
32	1.00022	142	1.01638
42	1.	152	1.01934
52	1.00021	162	1.02245
62	1.00083	172	1.02575
72	1.00180	182	1.02916
82	1.00312	192	1.03265
92	1.00477	202	1.03634
102	1.00672	212	1.04012
112	1.00880		

Proportions of cement for cast iron.

In mixing cement for cast iron, put one ounce of sal ammoniac to each hundred weight of borings, and use it without allowing it to heat. Multiply the length of any joint in feet by the breadth in inches, by the thickness in eighths, and by .3; the product will be the weight of dry borings, in lbs. avoirdupois, required to make cement to fill that joint nearly.

TABLE

Of boiling points of water holding various proportions of salt in solution.

	Parts of Salt.	Degrees of Faht.	Degrees of Reau.	Degrees of Cent.
Saturated solution.....	36.37	226.6	86.2	107.8
"	33.34	224.9	85.7	107.2
"	30.30	223.7	85.2	106.5
"	27.28	222.5	84.7	105.8
"	24.25	221.4	84.1	105.2
"	21.22	220.2	83.6	104.6
"	18.18	219	83	103.9
"	15.15	217.9	82.6	103.3
"	12.12	216.7	82.1	102.6
"	9.09	215.5	81.6	102
"	6.06	214.4	81.1	101.3
Sea water.....	3.03	213.2	80.5	100.7
Common water	0.00	212	80	100

To reduce any number of degrees of temperature on Fahrenheit's scale to the number of degrees of an equal temperature on Reaumer's scale; and also to the number of degrees of an equal temperature on the Centigrade scale or otherwise.

1.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32, multiplied by 4, and divided by 9, = Reaumer.

Thus, $77^{F.} - 32 = 45$, and $\frac{45 \times 4}{9} = 20^{R.}$

$$\text{Or, } \frac{\overset{\text{R.}}{20} \times 9}{4} = 45, \text{ and } 45 + 32 = \overset{\text{F.}}{77}.$$

2.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 4, and divided by 9, = Reaumer.

$$\text{Thus, } \overset{\text{F.}}{22} + 32 = 54, \text{ and } \frac{54 \times 4}{9} = \overset{\text{R.}}{24}$$

$$\text{Or, } \frac{\overset{\text{R.}}{24} \times 9}{4} = 54, \text{ and } 54 - 32 = \overset{\text{F.}}{22}.$$

3.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32, multiplied by 5, and divided by 9, = Centigrade,

$$\text{Thus, } \overset{\text{F.}}{167} - 32 = 135, \text{ and } \frac{135 \times 5}{9} = \overset{\text{C.}}{75}.$$

$$\text{Or, } \frac{\overset{\text{C.}}{75} \times 9}{5} = 135, \text{ and } 135 + 32 = \overset{\text{F.}}{167}.$$

4.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 5, and divided by 9, = Centigrade.

$$\text{Thus, } \overset{\text{F.}}{13} + 32 = 45, \text{ and } \frac{45 \times 5}{9} = \overset{\text{C.}}{25}.$$

$$\text{Or, } \frac{\overset{\text{C.}}{25} \times 9}{5} = 45, \text{ and } 45 - 32 = \overset{\text{F.}}{13}.$$

TABLE

Shouing the quantity and weight of a superficial foot of brick work, from half a brick to two and a half bricks in thickness.

Thickness by number.	Thickness in inches.	Number of bricks.	Weight in lbs. avoir.
½ brick	4½	4.58	40.23
1	9	9.15	80.37
1½	14	13.72	120.51
2	18½	18.3	160.74
2½	23½	22.875	200.93

NOTE.—The weight is independent of mortar.

1 Brick weighs 9 lbs. avoirdupois nearly; $12\frac{1}{2} = 1$ cwt., and $250 = 1$ ton.

TABLE

Of the specific gravities of those bodies chiefly used in machinery, building, &c., showing, in avoirdupois ounces and pounds, the weight of a cubic foot of each body; also the weight of a cubic inch, and the number of cubic inches in a pound, with multipliers to each, for finding the weight when the dimensions are given.

Names of Bodies.	Weight of a Cubic Foot.		Weight of a Cubic In.	No. of Cubic Inches in a Pound.	Multipliers.
	oz.	*lb.*	*oz.*		
Copper, cast.....	8788	549.25	5.086	3.146	.3178
Copper, sheet....	8915	557.18	5.159	3.103	.3225
Brass, cast.....	8396	524.75	4.852	3.293	.3037
Iron, cast.....	7271	454.43	4.203	3.802	.263
Iron, bar.....	7631	476.93	4.410	3.623	.276
Lead	11344	709.00	6.456	2.437	.4103
Steel, soft	7833	489.56	4.527	3.530	.2833
Steel, hard.....	7816	488.50	4.517	3.537	.2827
Zinc, cast	7190	449.37	4.156	3.845	.26
Tin, cast.....	7292	455.75	4.215	3.790	.2636
Bismuth.....	9880	619.50	5.710	2.789	.3585
Gun metal.....	8784	549.00	5.0775	3.147	.3177
Sand	1520	95.00	.8785	18.190	.055
Coal	1250	78.12	.7225	22.120	.0452
Brick	2000	125.00	1.156	13.824	.0723
Stone, paving	2416	151.00	1.396	11.443	.0873
Slate.....	2672	167.00	1.544	10.347	.0967
Marble.....	2742	171.37	1.585	10.083	.0991
White Lead.....	3160	197.50	1.826	8.750	.1143
Glass	2880	180.00	1.664	9.600	.1042
Tallow	945	59.06	.5462	29.258	.0342
Cork	240	15.00	.138	115.200	.0087
Larch	544	34.00	.315	50.823	.0197
Elm.....	556	34.75	.321	49.726	.0201
Pine, pitch.....	660	41.25	.382	41.890	.024
Beech	696	43.50	.403	39.724	.0252
Teak	745	46.56	.431	37.113	.027
Ash	760	47.50	.440	36.370	.0275
Mahogany	852	53.25	.493	32.449	.0308
Oak.....	970	60.62	.561	28.505	.0351
Oil of Turpentine	870	54.37	.503	31.771	.0315
Olive Oil.....	915	57.18	.529	30.220	.0331
Linseed Oil	932	58.25	.539	29.665	.0337
Spirits, proof.....	927	57.93	.536	29.828	.03352
Water, distilled..	1000	62.50	.578	27.648	.03617
Water, sea.....	1028	64.25	.594	26.894	.0372
Tar	1015	63.43	.587	27.242	.0367
Vinegar	1026	64.12	.593	26.949	.037
Mercury.....	13568	848 00	7.851	2.037	.4908

The 1st, 2d, 3d, and 4th columns require no further explanation than the titles they bear; the fifth column is to find the weight of any number of cubic inches, in avoirdupois pounds, of any of the different bodies required.

EXAMPLE 1.—Suppose a piece of cast iron to be $56\frac{3}{4}$ inches long, $16\frac{1}{2}$ inches broad, and $\frac{3}{4}$ of an inch in thickness, required its weight.

$56.75 \times 16.5 \times .75 = 702.28125$ cubic inches.
$\times .263 = 184.7$ lbs. nearly.

EXAMPLE 2.—Required the weight of an imperial gallon of proof spirits.

$277.274 \times .03352 = 9.294$ lbs. nearly.

EXAMPLE 3.—Required the thickness of metal for a concave copper ball, 8 inches diameter without, so as to sink to its centre in common water.

$8^3 \times .5236 = 268.0832$ cubic inches in the ball, $\div 2 = 134.0416$ cubic inches to be immersed, or cubic inches of water to be removed, —Then $134.0416 \times .578$ weight of a cubic inch of water $= 77.4760448$ ounces weight of water displaced, or, the weight of the copper ball; which divide by 5.159, the weight of a cubic inch of copper, $= 15.0176$ cubic inches of copper in the ball.

Again, $8^2 \times .7854 \times 4 = 202.0624$ square inches, the superficies of the ball; and $15.0176 \div 202.0624 = .0743$ inches, the required thickness of the copper nearly.

EXAMPLE 4.—Required the weight necessary to counterpoise a float of paving stone proper for a steam-engine boiler, &c., the float being 14 inches diameter and $2\frac{1}{2}$ inches thick.

$14^2 \times .7854 \times 2.5 = 384.846$ cubic inches. Then $384.846 \times .0873 = 33.597$ lbs. the weight of the stone. And, $384.846 \times .03617 = 13.919$ lbs. weight of water displaced; then, $33.597 - 13.919 = 19.678$ lbs. the counterpoise required.

RULES

FOR MAKING OR CORRECTING THE GAUGE POINTS ON THE ENGINEER'S SLIDE RULE.

The engineer's slide rule is an instrument of extensive use to mechanics, and almost every one who is in possession of the rule, is also, or may be, in ample possession of instructions; but I am not aware that any information has been given in any other work, for either correcting the old gauge points, or obtaining new ones; hence the following may be found useful:—

And first, by making the third column on the rule (or that marked III) the first of our observations, the others are rendered very simple; thus,

The third column is the number of cubic inches contained in a pound, foot, gallon, &c.

The second column is the numbers in the third column expressed in the decimals of a foot, or multiplied by .833.

The first column is the third column divided by 1728.

The fifth column is the third column divided by .7854.

The fourth column is the fifth column expressed in the decimals of a foot, or multiplied by .833.

The seventh column is the third column divided by .5236. And,

The 6th column is the 7th column divided by 1728.

DECIMAL APPROXIMATIONS FOR FACILITATING CALCULATIONS IN MENSURATION.

Lineal feet	multiplied by	.00019	= miles.
„ yards	„	.000568	= „
Square inches	„	.007	= square feet.
„ yards	„	.0002067	= acres.
Circular inches	„	.00546	= square feet.
Cylindrical inches	„	.0004546	= cubic feet.
„ feet	„	.02909	= cubic yards.
Cubic inches	„	.00058	= cubic feet.
„ feet	„	.03704	= cubic yards.
„ „	„	6.232	= imperial gallons.
„ inches	„	.003607	= „ „
Cylindrical feet	„	4.895	= „ „
„ inches	„	.002832	= „ „
Cubic inches	„	.263	= lbs. avs. of cast iron.
„	„	.281	= „ wrought do.
„	„	.283	= „ steel.
„	„	.3225	= „ copper.
„	„	.3037	= „ brass.
„	„	.26	= „ zinc.
„	„	.4103	= „ lead.
„	„	.2636	= „ tin.
„	„	.4908	= „ mercury.
Cylindrical inches	„	.2065	= „ cast iron.
„	„	.2168	= „ wrought iron.
„	„	.2223	= „ steel.
„	„	.2533	= „ copper.
„	„	.2385	= „ brass.
„	„	.2042	= „ zinc.
„	„	.3223	= „ lead.
„	„	.207	= „ tin.
„	„	.3854	= „ mercury.
Avoirdupois lbs.	„	.009	= cwts.
„	„	.00045	= tons.

DECIMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASURES.

One inch, the integer or whole number.

.96875	are equal to	$\frac{1}{32}$ &	.625	are equal to	$\frac{5}{8}$	28125	are equal to	& $\frac{1}{32}$
.9375		& $\frac{1}{16}$	.59375		& $\frac{9}{32}$	.25		
.90625		& $\frac{1}{32}$	.5625		& $\frac{1}{16}$	.21875		& $\frac{3}{32}$
.875			.53125		& $\frac{1}{32}$	.1875		& $\frac{1}{16}$
.84375		& $\frac{1}{32}$	.5			.15625		& $\frac{1}{32}$
.8125		& $\frac{1}{16}$	.46875		& $\frac{1}{32}$	.125		
.78125		& $\frac{1}{32}$	.4375		& $\frac{1}{16}$	.09375		$\frac{3}{32}$
.75			.40625		& $\frac{1}{32}$	.0625		$\frac{1}{16}$
.71875		& $\frac{5}{32}$	.375			.03125		$\frac{1}{32}$
.6875		& $\frac{1}{16}$	.34375		& $\frac{1}{32}$			
.65625		& $\frac{1}{32}$	.3125		& $\frac{1}{16}$			

One foot, or 12 inches, the integer.

.9166	are equal to	11 inches.	.4166	are equal to	5 in.	.0625	are equal to	$\frac{1}{16}$ of in.
.6333		10 „	.3333		4 „	.0528		„
.75		9 „	.25		3 „	.04166		„
.6666		8 „	.1666		2 „	.03125		„
.5833		7 „	.0833		1 „	.02083		„
.5		6 „	.07291		$\frac{7}{8}$ „	.01041		„

One yard, or 36 inches, the integer.

.9722	are equal to	35 inches.	.6389	are equal to	23 inches.	.3055	are equal to	11 inches.
.9445		34 „	.6111		22 „	.2778		10 „
.9167		33 „	.5833		21 „	.25		9 „
.8889		32 „	.5556		20 „	.2222		8 „
.8611		31 „	.5278		19 „	.1944		7 „
.8333		30 „	.5		18 „	.1666		6 „
.8056		29 „	.4722		17 „	.1389		5 „
.7778		28 „	.4445		16 „	.1111		4 „
.75		27 „	.4166		15 „	.0833		3 „
.7222		26 „	.3889		14 „	.0555		2 „
.6944		25 „	.3611		13 „	.0277		1 „
.6667		24 „	.3333		12 „			

TABLE

Containing the price of metals, or other materials, by the ton, cwt., quarter, or lb.

Per ton.		Per cwt.		Per qrtr.		Per lb.	Per ton.		Per cwt.		Per qrtr.		Per lb.	Per ton.		Per cwt.		Per qrtr.		Per lb.
£	s. d.	s.	d.	s.	d.	d.	£	s. d.	£	s. d.	s.	d.	d.	£	s. d.	£	s. d.	£	s. d.	d.
2	6 8	2	4	0	7	½	14	10 0	0	14 6	3	7½	..	32	10 0	1	12 6	0	8	1½
2	10 0	2	6	0	7½	..	14	15 0	0	14 9	3	8¼	..	32	13 4	1	12 8	0	8	2
2	15 0	2	9	0	8¼	..	15	0 0	0	15 0	3	9	..	33	0 0	1	13 0	0	8	3
3	0 0	3	0	0	9	..	15	5 0	0	15 3	3	9¾	..	33	10 0	1	13 6	0	8	4½
3	5 0	3	3	0	9¾	..	15	10 0	0	15 6	3	10¼	..	34	0 0	1	14 0	0	8	6
3	10 0	3	6	0	10½	..	15	15 0	0	15 9	3	11¼	..	34	10 0	1	14 6	0	8	7½
3	15 0	3	9	0	11¼	..	16	0 0	0	16 0	4	0	..	35	0 0	1	15 0	0	8	9
4	0 0	4	0	1	0	..	16	5 0	0	16 3	4	0¾	..	35	10 0	1	15 6	0	8	10½
4	5 0	4	3	1	0¾	..	16	6 8	0	16 4	4	1	1⅓	36	0 0	1	16 0	0	9	0
4	10 0	4	6	1	1½	..	16	10 0	0	16 6	4	1¼	..	36	10 0	1	16 6	0	9	1½
4	13 4	4	8	1	2	⅓	16	15 0	0	16 9	4	2¼	..	37	0 0	1	17 0	0	9	3
4	15 0	4	9	1	2¼	..	17	0 0	0	17 0	4	3	..	37	6 8	1	17 4	0	9	4
5	0 0	5	0	1	3	..	17	5 0	0	17 3	4	3¾	..	37	10 0	1	17 6	0	9	4½
5	5 0	5	3	1	3¾	..	17	10 0	0	17 6	4	4½	..	38	0 0	1	18 0	0	9	6
5	10 0	5	6	1	4½	..	17	15 0	0	17 9	4	5¼	..	38	10 0	1	18 6	0	9	7½
5	15 0	5	9	1	5¼	..	18	0 0	0	18 0	4	6	..	39	0 0	1	19 0	0	9	9
6	0 0	6	0	1	6	..	18	5 0	0	18 3	4	6¾	..	39	10 0	1	19 6	0	9	10½
6	5 0	6	3	1	6¾	..	18	10 0	0	18 6	4	7½	..	39	13 4	1	19 8	0	9	11
6	10 0	6	6	1	7½	..	18	13 4	0	18 8	4	8	2	40	0 0	2	0 0	0	10	0
6	15 0	6	9	1	8¼	..	18	15 0	0	18 9	4	8¼	..	40	10 0	2	0 6	0	10	1½
7	0 0	7	0	1	9	¾	19	0 0	0	19 0	4	9	..	41	0 0	2	1 0	0	10	3
7	5 0	7	3	1	9¾	..	19	5 0	0	19 3	4	9¾	..	41	10 0	2	1 6	0	10	4½
7	10 0	7	6	1	10½	..	19	10 0	0	19 6	4	10½	..	42	0 0	2	2 0	0	10	6
7	15 0	7	9	1	11¼	..	19	15 0	0	19 9	4	11¼	..	44	6 8	2	4 4	0	11	1
8	0 0	8	0	2	0	..	20	0 0	1	0 0	5	0	..	46	13 4	2	6 8	0	11	8
8	5 0	8	3	2	0¾	..	20	10 0	1	0 6	5	1½	..	49	0 0	2	9 0	0	12	3
8	10 0	8	6	2	1½	..	21	0 0	1	1 0	5	3	2¼	51	6 8	2	11 4	0	12	10
8	15 0	8	9	2	2¼	..	21	10 0	1	1 6	5	4½	..	53	13 4	2	13 8	0	13	5
9	0 0	9	0	2	3	..	22	0 0	1	2 0	5	6	..	56	0 0	2	16 0	0	14	0
9	5 0	9	3	2	3¾	..	22	10 0	1	2 6	5	7½	..	58	6 8	2	18 4	0	14	7
9	6 8	9	4	2	4	1	23	0 0	1	3 0	5	9	..	60	13 4	3	0 8	0	15	2
9	10 0	9	6	2	4½	..	23	6 8	1	3 4	5	10	2½	63	0 0	3	3 0	0	15	9
9	15 0	9	9	2	5¼	..	23	10 0	1	3 6	5	10½	..	65	6 8	3	5 4	0	16	4
10	0 0	10	0	2	6	..	24	0 0	1	4 0	6	0	..	67	13 4	3	7 8	0	16	11
10	5 0	10	3	2	6¾	..	24	10 0	1	4 6	6	1½	..	70	0 0	3	10 0	0	17	6
10	10 0	10	6	2	7½	..	25	0 0	1	5 0	6	3	..	72	6 8	3	12 4	0	18	1
10	15 0	10	9	2	8¼	..	25	10 0	1	5 6	6	4½	..	74	13 4	3	14 8	0	18	8
11	0 0	11	0	2	9	..	25	13 4	1	5 8	6	5	2¾	77	0 0	3	17 0	0	19	3
11	5 0	11	3	2	9¾	..	26	0 0	1	6 0	6	6	..	79	6 8	3	19 4	0	19	10
11	10 0	11	6	2	10½	..	26	10 0	1	6 6	6	7½	..	81	13 4	4	1 8	1	0	5
11	13 4	11	8	2	11	1⅓	27	0 0	1	7 0	6	9	..	84	0 0	4	4 0	1	1	0
11	15 0	11	9	2	11¼	..	27	10 0	1	7 6	6	10½	..	86	6 8	4	6 4	1	1	7
12	0 0	12	0	3	0	..	28	0 0	1	8 0	7	0	3	88	13 4	4	8 8	1	2	2
12	5 0	12	3	3	0¾	..	28	10 0	1	8 6	7	1½	..	91	0 0	4	11 0	1	2	9
12	10 0	12	6	3	1½	..	29	0 0	1	9 0	7	3	..	93	6 8	4	13 4	1	3	4
12	15 0	12	9	3	2¼	..	29	10 0	1	9 6	7	4½	..	95	13 4	4	15 8	1	3	11
13	0 0	13	0	3	3	..	30	0 0	1	10 0	7	6	..	98	0 0	4	18 0	1	4	6
13	5 0	13	3	3	3¾	..	30	6 8	1	10 4	7	7	2¾	100	6 8	5	0 4	1	5	1
13	10 0	13	6	3	4½	..	30	10 0	1	10 6	7	7½	..	102	13 4	5	2 8	1	5	8
13	15 0	13	9	3	5¼	..	31	0 0	1	11 0	7	9	..	107	6 8	5	7 4	1	6	10
14	0 0	14	0	3	6	1½	31	10 0	1	11 6	7	10½	..	112	0 0	5	12 0	1	8	0
14	5 0	14	3	3	6¾	..	32	0 0	1	12 0	8	0	..							

A TABLE

CONTAINING THE

CIRCUMFERENCES, SQUARES, CUBES,

AND

AREAS OF CIRCLES,

From $\frac{1}{16}$*th to* 100 *inches, advancing by a* $\frac{1}{16}$*th, and also the side of equal square, advancing at an equal ratio.*

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
1/16	.1963	.0039	.00024	.0030	.0554
1/8	.3927	.0156	.00195	.0122	.1107
3/16	.5890	.0351	.00659	.0276	.1661
1/4	.7854	.0625	.01562	.0490	.2215
5/16	.9817	.0976	.03051	.0767	.2669
3/8	1.1781	.1406	.05273	.1104	.3223
7/16	1.3744	.1914	.08374	.1503	.3771
1/2	1.5708	.25	.125	.1963	.4331
9/16	1.7671	.3164	.17797	.2485	.4995
5/8	1.9635	.3906	.24414	.3068	.5438
11/16	2.1598	.4726	.32495	.3712	.6093
3/4	2.3562	.5625	.42187	.4417	.6646
13/16	2.5525	.6601	.53637	.5185	.7200
7/8	2.7489	.7656	.66992	.6013	.7754
15/16	2.9452	.8789	.81397	.6903	.8308
1 in.	3.1416	1	1	.7854	.8862
1/16	3 3379	1.1289	1.19946	.8861	.9416
1/8	3.5343	1 2656	1.42381	.9940	.9969
3/16	3.7306	1.4101	1.67456	1.1075	1.0524
1/4	3.9270	1.5625	1.95312	1.2271	1.0775
5/16	4.1233	1.7226	2.26098	1.3529	1.1631
3/8	4 3197	1 8906	2.59960	1.4848	1.2185
7/16	4.5160	2.0664	2.97045	1.6229	1.2740
1/2	4.7124	2.25	3.375	1.7671	1.3293
9/16	4.9087	2.4414	3.81469	1.9175	1.3846
5/8	5.1051	2.6406	4.29101	2.0739	1.4401
11/16	5.3014	2.8476	4.80541	2.2365	1.4954
3/4	5.4978	3.0625	5.35937	2.4052	1.5508
13/16	5.6941	3.2851	5.95434	2.5801	1.6062
7/8	5.8905	3.5156	6.59179	2.7611	1.6616
15/16	6.0868	3.7539	7.27319	2.9483	1.7170
2 in.	6 2832	4	8	3.1416	1.7724
1/16	6.4795	4.2539	8.7736	3.3411	1.8278
1/8	6.6759	4.5156	9.5957	3 5465	1.8831
3/16	6.8722	4.7851	10.4675	3.7582	1.9385
1/4	7.0686	5.0625	11.3906	3.9760	1.9939
5/16	7.2649	5.3476	12.3663	4.2001	2.0493
3/8	7 4613	5.6406	13.3964	4.4302	2.1047
7/16	7.6576	5.9414	14.4822	4.6664	2 1601
1/2	7.8540	6.25	15.625	4.9087	2.2155
9/16	8 0503	6 5664	16.8265	5 1573	2.2709
5/8	8.2467	6.8906	18.0878	5.4119	2.3262
11/16	8.4430	7.2226	19.4108	5.6727	2 3816
3/4	8.6394	7.5625	20.7968	5.9395	2.4370
13/16	8.8357	7.9101	22.2472	6 2126	2 4924
7/8	9.0321	8.2656	23.7636	6.4918	2 5478
15/16	9.2284	8.6289	25.3474	6.7772	2.6032

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
3 *in.*	9.4248	9	27	7.0686	2.6586
1/16	9.6211	9 3789	28.7228	7.3662	2.7140
1/8	9 8175	9.7656	30.5175	7.6699	2.7694
3/16	10 0138	10.1601	32.3353	7.9798	2.8247
1/4	10.2102	10 5625	34.3281	8.2957	2.8801
5/16	10.4065	10 9726	36.3467	8.6179	2 9355
3/8	10.6029	11.3906	38.4433	8.9462	2.9909
7/16	10.7992	11.8164	40.6178	9.2806	3 0463
1/2	10.9956	12 25	42.875	9 6211	3.1017
9/16	11.1919	12.6914	45.2031	9.9678	3.1570
5/8	11.3883	13.1406	47.6347	10.3206	3.2124
11/16	11.5846	13.5976	49.9461	10.6796	3.2678
3/4	11.7810	14.0625	52 7343	11.0446	3.3232
13/16	11.9773	14.5351	55.3930	11.4159	3.3786
7/8	12.1737	15.1056	58.1855	11.7932	3.4340
15/16	12.3700	15.5039	61.0256	12.1768	3.4894
4 *in.*	12.5664	16	64	12.5664	3.5448
1/16	12.7627	16.5039	67.0471	12.9622	3.6002
1/8	12 9591	17.0156	70.1894	13.3640	3.6555
3/16	13.1554	17.5351	73.4282	13.7721	3.7110
1/4	13.3518	18.0625	76.7656	14.1862	3.7663
5/16	13 5481	18.5976	80.2021	14.6066	3.8217
3/8	13 7445	19.1406	83.7402	15.0331	3.8771
7/16	13 9408	19 6914	87.3804	15.4657	3.9325
1/2	14,1372	20 25	91.125	15.9043	3.9880
9/16	14.3335	20.8164	94 9748	16.3492	4.0433
5/8	14.5299	21.3906	98 9316	16.8001	4.0987
11/16	14 7262	21.9726	101.8965	17.2573	4.1541
3/4	14 9226	22.5625	107.1718	17.7205	4.2095
13/16	15.1189	23.1601	111.4679	18.1900	4.2648
7/8	15.3153	23.7656	115.8574	18.6655	4.3202
15/16	15.5716	24.3789	120.2708	19.1472	4.3756
5 *in.*	15.7080	25	125	19.6350	4.4310
1/16	15.9043	25 6289	129.7463	20.1290	4.4864
1/8	16.1007	26.2656	134.6113	20.6290	4.5417
3/16	16.2970	26 9101	138 5961	21.1252	4.5971
1/4	16.4934	27.5625	144.7031	21.6475	4.6525
5/16	16 6897	28 2226	149.9306	22.1661	4.7079
3/8	16.8861	28 8906	155.2871	22.6907	4.7633
7/16	17.0824	29.5664	160 7673	23.2215	4.8187
1/2	17.2788	30 25	166.375	23.7583	4.8741
9/16	17.4751	30.9414	172.1115	24.3014	4.9294
5/8	17.6715	31.6406	177.9785	24.8505	4.9848
11/16	17.8678	32.3476	183.9669	25.4058	5.0402
3/4	18.0642	33.0625	190 1093	25.9672	5.0956
13/16	18.2605	33.7851	196.3759	26.5348	5.1510
7/8	18.4569	34 5156	202.7792	27.1085	5.2064
15/16	18.6532	35.2539	209.3130	27.6884	5.2618

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
6 in.	18.8496	36	216	28.2744	5.3172
1/16	19.0459	36.7539	222.8205	28.8665	5.3726
1/8	19.2423	37.5156	229.7832	29.4647	5.4280
3/16	19.4386	38.2851	236.8890	30.0798	5.4834
1/4	19.6350	39.0625	244.1406	30.6796	5.5388
5/16	19.8313	39.8476	249.2654	31.2964	5.5942
3/8	20.0277	40.6406	259.0839	31.9192	5.6495
7/16	20.2240	41.4414	256.7605	32.5481	5.7049
1/2	20.4204	42.25	274.625	33.1831	5 7603
9/16	20.6167	43.0664	282.6232	33.8244	5.8157
5/8	20.8131	43.8906	290.7753	34.4717	5.8711
11/16	21.0094	44.7226	299.0823	35.1252	5.9265
3/4	21.2058	45.5625	307.5468	35.7847	5.9819
13/16	21.4021	46.4101	316.1688	36.4505	6.0373
7/8	21.5985	47.2656	324.9511	37.1224	6.0927
15/16	21.7948	48.1289	333.8943	37.8005	6.1480
7 in.	21.9912	49	343	38.4846	6.2034
1/16	22.1875	49.8789	349.5702	39.1749	6.2588
1/8	22.3839	50.7656	361.7040	39.8713	6.3142
3/16	22.5802	51.6601	371.3070	40.5469	6.3696
1/4	22.7766	52.5625	381.0781	41.2825	6.4350
5/16	22.9729	53.4726	391.0184	41.9974	6.4904
3/8	23.1693	54.3906	401.1308	42.7184	6.5358
7/16	23.3656	55.3164	411.4158	43.4455	6.5912
1/2	23 5620	56.25	421.875	44.1787	6.6465
9/16	23.7583	57.1914	432.5100	44.9181	6.7020
5/8	23.9547	58.1406	443.3222	45.6636	6.7573
11/16	24.1510	59.0976	454.3129	46.4153	6.8127
3/4	24.3474	60.0625	465.4843	47.1730	6.8681
13/16	24.5437	61.0351	476.8368	47.9370	6.9235
7/8	24.7401	62.0156	488.3730	48.7070	6.9789
15/16	24.9364	63.0039	500.0935	49.4833	7.0343
8 in.	25.1328	64	512	50.2656	7.0897
1/16	25.3291	65.0039	524.1939	51 0541	7 1451
1/8	25.5255	66.0156	536.3769	51.8486	7.2005
3/16	25.7218	67.0351	548.8499	52.8994	7.2559
1/4	25.9182	68.0625	561.5156	53.4562	7.3112
5/16	26.1145	69.0976	574.3739	54.2748	7.3666
3/8	26.3109	70.1406	587.4277	55.0885	7.4220
7/16	26.5072	71.1914	600.6775	55.9138	7.4774
1/2	26.7036	72.25	614.125	56.7451	7.5328
9/16	26.8999	73.3164	627.7717	57.5887	7.5882
5/8	27.0963	74.3906	641.6191	58.4264	7.6436
11/16	27.2926	75.4726	655.6683	59.7762	7.6990
3/4	27.4890	76.5625	669.9218	60.1321	7.7544
13/16	27.6853	77.6601	684.3797	60.9943	7.8098
7/8	27.8817	78.7656	699.0449	61.8625	7.8651
15/16	28.0780	79.8789	713.9177	62.7369	7.9205

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
9 in.	28.2744	81	729	63.6174	7.9760
1/16	28.4707	82.1289	744.2932	64.5041	8.0312
1/8	28.6671	83.2656	759.7988	65.3968	8.0866
3/16	28.8634	84.4101	775.5378	66.2957	8.1420
1/4	29.0598	85.5625	791.4531	67.2007	8.1974
5/16	29.2561	86.7226	807.8043	68.1120	8.2527
3/8	29.4525	87.8906	823.9746	69.0293	8.3081
7/16	29.6488	89.0664	840.5642	69.9528	8.3635
1/2	29.8452	90.25	857.375	70.8823	8.4190
9/16	30.0415	91.4414	874.3084	71.8181	8.4743
5/8	30.2379	92.6406	891.6660	72.7599	8.5297
11/16	30.4342	93.8476	909.1487	73.7079	8.5851
3/4	30.6306	95.0625	926.8593	74.6620	8.6405
13/16	30.8269	96.2851	944.7976	75.6223	8 6959
7/8	31.0233	97.5156	962.9667	76.5887	8.7513
15/16	31.2196	98.7539	981.3669	77.5613	8.8066
10 in.	31.4160	100	1000	78.5400	8 8620
1/16	31.6123	101.2539	1018.860	97.5248	8.9174
1/8	31.8087	102.5156	1037.970	80.5157	9.9728
3/16	32.0050	103.7851	1057.310	81.5128	9.0282
1/4	32.2014	105.0625	1076.890	82.5160	9.0836
5/16	32.3977	106.3476	1096.709	83.5254	9.1390
3/8	32.5941	107.6406	1116.771	84.5409	9.1943
7/16	32.7904	108.9414	1137.075	85.5626	9.2497
1/2	32.9868	110.25	1157.625	86.5903	9.3051
9/16	33.1831	111.5664	1178.420	87.6243	9.3605
5/8	33.3795	112.8906	1199.462	88 6643	9.4159
11/16	33.5758	114.2226	1220.755	89 7105	9.4713
3/4	33.7722	115.5625	1242.296	90.7627	9.5267
13/16	33 9685	116.9101	1264.090	91.8212	9.5821
7/8	34.1649	118.2656	1286.138	92.8858	9.6375
15/16	34.3612	119.6289	1308.430	93.9566	9 6929
11 in.	34 5576	121	1331	95.0334	9.7482
1/16	34.7539	122.3789	1353.816	96.1164	9.8036
1/8	34.9503	123.7656	1376.892	97.2053	9.8590
3/16	35.1466	125.1601	1400.228	98 3008	9.9144
1/4	35.3430	126.5625	1423.828	99.4021	9.9698
5/16	35.5393	127.9726	1447.690	100.5097	10.0252
3/8	35.7357	129.3906	1471.818	101.6234	10.0806
7/16	35.9320	130.8164	1496.412	102.7432	10.1360
1/2	36.1284	132.25	1520.875	103.8691	10.1914
9/16	36.3247	133.6914	1535.796	105.0012	10.2467
5/8	36.5211	135.1406	1571.009	106.1394	10.3021
11/16	36.7174	136.5976	1596.534	107.2838	10.3575
3/4	36.9138	138.0625	1622.234	108.4342	10.4130
13/16	37.1101	139.5351	1648.358	109.5909	10.4683
7/8	37.3065	141.0156	1674.560	110 7536	10.5237
15/16	37.5028	142.5039	1701.140	111.9226	10.5791

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
12 *in.*	37.6992	144	1728	113.0976	10 6345
1/16	37.8955	145.5039	1755.160	114 2788	10.6899
1/8	38.0919	147.0156	1782.564	115.4660	10.7453
3/16	38.2882	148.5351	1810.271	116.6645	10.8007
1/4	38.4846	150.0625	1838.265	117.8590	10.8560
5/16	38.6809	151.5976	1866.539	119.0648	10.9114
3/8	38.8773	153.1406	1895.115	120.2766	10.9668
7/16	39.0736	154.6914	1923.974	121.4946	11.0222
1/2	39.2700	156 25	1953.125	122.7187	11.0776
9/16	39 4663	157.8164	1982.568	123.9490	11.1339
5/8	39.6627	159.3906	2012.306	125.1854	11.1884
11/16	39.8590	160.9726	2042.339	126.4279	11.2437
3/4	40.0554	162.5625	2072.671	127.6765	11.2991
13/16	40.2517	164.1601	2103.301	128 8999	11.3544
7/8	40.4481	165 7656	2134.232	130.1923	11.4099
15/16	40.6444	167.3789	2165.514	131.4279	11.4652
13 *in.*	40.8408	169	2197	132.7326	11.5206
1/16	41.0371	170.6289	2228 840	134.0120	11.5760
1/8	41.2338	172.2656	2260 986	135.2974	11.6314
3/16	41.4298	173.9101	2293.439	136 5890	11 6868
1/4	41.6262	175.5625	2326 203	137.8867	11.7422
5/16	41.8225	177.2226	2359.275	139.1907	11.7976
3/8	42 0189	178.8906	2392.661	140.5007	11.8530
7/16	42.2152	180.5664	2426.361	141.8169	11.9083
1/2	42.4116	182.25	2460.375	143.1391	11 9637
9/16	42.6079	183.9414	2494.705	144.4726	12.0191
5/8	42.8043	185.6406	2529 353	145.8021	12.0745
11/16	43.0006	187.3476	2564.321	147.1428	12.1299
3/4	43.1970	189.0625	2599.609	148.4896	12.1853
13/16	43 3933	190 7851	2634.819	149 8426	12.2407
7/8	43.5897	192.5156	2671.154	151.2017	12.2961
15/16	43.7860	194.2539	2707.413	152.5670	12.3515
14 *in.*	43.9824	196	2744	153.9384	12 4068
1/16	44.1787	197.7539	2780.914	155.3159	12.4622
1/8	44.3751	199.5156	2818.157	156.6995	12 5176
3/16	44.5714	201.2851	2855.732	158.0893	12.5730
1/4	44.7676	203.0625	2893.640	159.4852	12 6284
5/16	44.9641	204.8476	2931.781	160.8374	12.6838
3/8	45.1605	206.6406	2970.458	162.2956	12.7392
7/16	45.3568	208.4414	3009.372	163.7099	12.7946
1/2	45.5532	210.25	3048.625	165.1303	12.8500
9/16	45.7495	212.0664	3088.217	166.5569	12 9053
5/8	45 9459	213 8906	3128.150	167.9896	12 9607
11/16	46.1422	215.7226	3168.425	169.4285	13.0161
3/4	46.3386	217.5625	3209.046	170.8735	13.0715
13/16	46.5349	219.4101	3250.012	172.3247	13.1270
7/8	46.7313	221.2656	3291.325	173.7820	13.1823
15/16	*46.9276*	223.1289	3332.988	175.2455	13.2377

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
15 in.	47.1240	225.	3375	176 7150	13.2930
1/16	47.3203	226.8789	3414.781	178.1907	13.3484
1/8	47.5167	228.7656	3460.079	179 6725	13.4038
3/16	47.7130	230.6601	3503.150	181.1105	13.4592
1/4	47.9094	232.5625	3546.578	182.6545	13.5146
5/16	48.1057	234.4726	3590.361	184.1548	13.5700
3/8	48.3021	236.3906	3633.505	185.6612	13.6254
7/16	48 4984	238.3164	3679.009	187.1737	13.6608
1/2	48.6948	240.25	3723.875	188.6923	13.7361
9/16	48.8911	242.1914	3769.103	190.2171	13.7915
5/8	49.0875	244.1406	3814.696	191.7480	13 8470
11/16	49.2838	246.0976	3860.856	193 3351	13.9023
3/4	49.4802	248.0625	3906.984	194.8282	13.9577
13/16	49.6765	250.0351	3953.680	196.3776	14.0131
7/8	49.8729	252.0156	4000 747	197.9330	14.0685
15/16	50.0692	254.0039	4048.187	199.4947	14.1240
16 in.	50.2656	256.	4096	201.0624	14.1792
1/16	50.4619	258.0039	4144.187	202.6363	14.2346
1/8	50.6583	260.0156	4192.751	204.2162	14.2900
3/16	50.8546	262.0351	4241.693	205.8024	14.3454
1/4	51.0510	264.0625	4291.015	207.3946	14.4008
5/16	51.2473	266.0976	4360.717	208.9931	14.4561
3/8	51.4437	268.1406	4390.802	210.5976	14.5115
7/16	51.6400	270.1914	4441 271	212.2083	14.5670
1/2	51.8364	272.25	4492.125	213.8251	14.6223
9/16	52.0327	274.3164	4544.366	215.4481	14.6777
5/8	52 2291	276 3906	4594.993	217.0772	14.7321
11/16	52.4254	278.4726	4657.011	218.7124	14.7885
3/4	52.6218	280.5625	4699 421	220.3537	14.8439
13/16	52.8181	282.6601	4752.223	222.0013	14.8993
7/8	53 0145	284.7656	4805.419	223.6549	14.9547
15/16	53.2108	286.8789	4859.011	225.3147	15.0101
17 in.	53.4072	289.	4913	226.9806	15.0654
1/16	53.6035	291.1289	4967.286	228.6527	15.1208
1/8	53.7999	293 2656	5022 173	230.3308	15.1762
3/16	53.9962	295 4101	5077.361	232.0151	15.2316
1/4	54.1926	297.5625	5132.953	233 7055	15.2869
5/16	54.3889	299.7226	5188.947	235.4022	15.3424
3/8	54.5853	301.8906	5245.349	237.1049	15.3977
7/16	54.7816	304.0664	5302.157	238.8138	15.4531
1/2	54.9780	306.25	5359.375	240.5287	15.5085
9/16	55.1743	308.4414	5419.002	242 2499	15 5639
5/8	55.3707	310.6406	5475.040	243.9771	15.6193
11/16	55 5670	312.8476	5533.493	245.7105	15.6747
3/4	55.7634	315.0625	5592.359	247.4500	15.7301
13/16	55.9597	317.2851	5651.640	249.1952	15.7855
7/8	56.1561	319.5156	5711.341	250.9475	15.8408
15/16	56.3524	321.7539	5771.460	252.7050	15.8962

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
18 *in.*	56.5488	324	5832	254.4696	15.9516
1/16	56.7451	326.2539	5892.961	256.2398	16.0070
1/8	56.9415	328.5156	5954.345	258.0161	16.0624
3/16	57.1378	330.7851	6016.154	259.7986	16.1178
1/4	57.3342	333.0625	6078.390	261.5872	16.1732
5/16	57.5305	335.3476	6141.053	263.3820	16.2285
3/8	57.7269	337.6406	6204.146	265.1829	16.2839
7/16	57.9232	339.9414	6267.669	266.9900	16.3393
1/2	58.1196	342.25	6331.625	268.8031	16.3947
9/16	58.2159	344.5664	6396.010	270.6225	16.4501
5/8	58.5123	346.8906	6460.837	272.4479	16.5055
11/16	58.7806	349.2226	6566.497	274.2895	16.5609
3/4	58.9056	351.5625	6591.796	276.1171	16.6163
13/16	59.1013	353.9101	6658.933	277.9610	16.6717
7/8	59.2977	356.2656	6724.513	279.8110	16.7270
15/16	59.4940	358.6289	6791.534	281.1672	16.7824
19 *in.*	59.6904	361	6859	283.5294	16.8378
1/16	59.8867	363.3789	6926 910	285.3978	16.8932
1/8	60 0831	365.7656	6995.267	287.2723	16.9486
3/16	60.2794	368.1601	7065.672	289.4030	17.0040
1/4	60 4758	370.5625	7132.328	291.0397	17.0600
5/16	60.6721	372.9726	7203.033	292.9324	17.1147
3/8	60.8685	375.3906	7273.192	294.8312	17.1701
7/16	61.0648	377.8164	7343.785	296.7367	17.2255
1/2	61.2612	380.25	7414.875	298.6483	17.2809
9/16	61.4575	382.6914	7486.410	300.5658	17.3363
5/8	61.6539	385.1406	7558.384	302.4894	17.3917
11/16	61.8502	387.5976	7630.827	304.4192	17.4471
3/4	62.0466	390.0625	7703.734	306.3550	17.5025
13/16	62.2429	392.5351	7777.111	308.2971	17.5579
7/8	62 4393	395.0156	7850.935	310.2452	17.6132
15/16	62.6356	397.5039	7925.234	312.1996	17.6686
20 *in.*	62.8320	400	8000	314.1600	17.7240
1/16	63.0283	402.5039	8075 234	316.1266	17.7794
1/8	63.2247	405.0156	8150.939	318 0992	17.8348
3/16	63.4210	407.5351	8227.114	320.0781	17.8902
1/4	63.6174	410.0625	8303.765	322.0630	17.9456
5/16	63.8137	412.5976	8380.888	324.0542	18.0010
3/8	64.0101	415.1406	8458.489	326.0514	18.0563
7/16	64.2064	417.6914	8536.567	328.0548	18.1117
1/2	64.4028	420.25	8615.125	330.0643	18.1671
9/16	64.5991	422.8164	8694.162	332.0800	18.2225
5/8	64.7955	425.3906	8773.681	334.1018	18.2779
11/16	64.9918	427.9726	8853.683	336.1297	18.3333
3/4	65.1882	430.5625	8934.171	338.1637	18.3887
13/16	65.3845	433.1601	9015.144	340.2040	18.4441
7/8	65 5809	435.7656	9096.607	342.2503	18.4995
15/16	65.7772	438.3789	9178.558	344.3028	18.5549

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
21 *in.*	65.7936	441	9261	346 3614	18.6102
1/16	66.1669	443.6289	9343.933	348.4267	18.6656
1/8	66.3663	446.2656	9427.360	350.4970	18.7210
3/16	66.5626	448.9101	9511.282	352.5740	18.7764
1/4	66.7590	451.5625	9595.703	354.6571	18.8318
5/16	66.9553	454.2226	9680.617	356.7465	18.8872
3/8	67.1517	456.8906	9766.036	358.8419	18.9425
7/16	67.3480	459.5664	9853.954	360.9435	18.9979
1/2	67.5444	462.25	9938.375	363.0511	19.0533
9/16	67.7407	464.9414	10025.29	365.1650	19.1087
5/8	67.9371	467.6406	10112.72	367.2849	19.1641
11/16	68.1334	470.3476	10200.66	369.4110	19.2195
3/4	68.3298	473.0625	10289.11	371.5432	19.2749
13/16	68.5261	475.7851	10378.06	373.6816	19.3303
7/8	68.7225	478.5156	10467.52	375.8261	19.3857
15/16	68.9188	481.2509	10557.54	377.9768	19.4410
22 *in.*	69.1152	484	10648	380.1336	19.4964
1/16	69.3115	486.7539	10739.00	382.2965	19.5518
1/8	69.5079	489.5156	10830.53	384.4655	19 6072
3/16	69.7042	492.2851	10922.57	386.6907	19.6626
1/4	69.9006	495.0625	11015.14	388.8220	19.7180
5/16	70.0969	497.8476	11108.22	391.0095	19.7734
3/8	70.2933	500.6406	11201.83	393.2031	19.8287
7/16	70.4806	503.4414	11295.96	395.4029	19.8841
1/2	70.6860	506.25	11390.62	397.6087	19.9395
9/16	70.8823	509.0664	11485.81	399.8207	19.9949
5/8	71.0787	511.8906	11581.52	402.0388	20.0503
11/16	71.2750	514.7226	11677.76	404.2631	20.1057
3/4	71.4714	517.5625	11774.54	406.4935	20.1611
13/16	71.6677	520.4101	11871.85	408.7301	20.2165
7/8	71.8641	523.2656	11969.70	410.9728	20.2719
15/16	72.0604	526.1289	12068.08	413.2317	20.3272
23 *in.*	72.2568	529	12167	415.4766	20.3826
1/16	72.4531	531.8789	12266.45	417.7377	20.4380
1/8	72.6495	534.7656	12366.45	420.0049	20.4934
3/16	72.8458	537.6601	12466.99	422.2783	20.5490
1/4	73.0422	540.5625	12568.07	424.5577	20.6042
5/16	73.2385	543.4726	12669.70	426.3434	20.6596
3/8	73.4349	546.3906	12771.88	429.1352	20.7150
7/16	73.6312	549.3164	12874.60	431.4331	20.7703
1/2	73.8276	552.25	12977.87	433.7371	20.8257
9/16	74.0239	555.1914	13081.69	436.0473	20.8811
5/8	74.2203	558.1406	13185.98	438.3636	20.9365
11/16	74.4166	561.0976	13290.99	440.6811	20.9919
3/4	74.6130	564.0625	13396.48	443.0146	21.0473
13/16	74.8093	567.0351	13502.52	445.3539	21.1027
7/8	75.0057	570.0156	13609.12	447.6992	21.1581
15/16	75.2020	573.0039	13716.28	450.0418	21.2134

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
24 *in.*	75.3984	576	13824	452.3904	21.2688
1/16	75.5947	579.0039	13932.281	454.7497	21.3242
1/8	75.7911	582.0156	14041.126	457.1150	21.3796
3/16	75.9874	585.0351	14150.536	459.4866	21.4350
1/4	76.1838	588.0625	14260.515	461.8642	21.4904
5/16	76.3801	591.0976	14371.066	464.2481	21.5558
3/8	76.5765	594.1406	14482.177	466.6380	21.6012
7/16	76.7728	597.1914	14593.864	469.0341	21.6566
1/2	76.9692	600.25	14706.125	471.4363	21.7119
9/16	77.1655	603.3164	14818.959	473.8447	21.7673
5/8	77.3619	606.3906	14932.368	476.2592	21.8227
11/16	77.5582	609.4726	15046.354	478.6798	21.8781
3/4	77.7546	612.5625	15160.921	481.1065	21.9335
13/16	77.9509	615.6601	15285.065	483.5395	21.9889
7/8	78.1473	618.7656	15391.794	485.9785	22.0443
15/16	78.3436	621.8789	15508.105	488.4237	22.0997
25 *in*	78.5400	625	15625	490.8750	22.1550
1/16	78.7363	628.1289	15742.480	493.3325	22.2104
1/8	78.9327	631.2656	15860.548	495.7960	22.2658
3/16	79.1290	634.4101	15979.204	498.2657	22.3212
1/4	79.3254	637.5625	16098.453	500.7415	22.3766
5/16	79.5217	640.7226	16218.290	503.2236	22.4320
3/8	79.7181	643.8906	16338.323	505.7117	22.4873
7/16	79.9144	647.0664	16459.751	508.2060	22.5427
1/2	80.1108	650.25	16581.375	510.7063	22.5981
9/16	80.3071	653.4414	16703.595	513.2129	22.6535
5/8	80.5035	656.6406	16826.415	515.7255	22.7089
11/16	80.6998	659.8476	16949.824	518.2443	22.7643
3/4	80.8962	663.0625	17073.859	520.7692	22.8197
13/16	81.0925	666.2851	17195.482	523.3003	22.8751
7/8	81.2889	669.5156	17323.716	525.8375	22.9305
15/16	81.4852	672.7539	17449.552	5283.809	22.9858
26 *in.*	81.6816	676	17576	530.9304	23.0412
1/16	81.8779	679.2539	17703.054	533.4860	23.0966
1/8	82.0743	682.5156	17830.720	536.0477	23.1520
3/16	82.2706	685.7851	17924.708	538.6156	23.2074
1/4	82.4670	689.0625	18087.890	541.1896	23.0628
5/16	82.6633	692.3476	18217.396	543.7698	23.3182
3/8	82.8597	695.6406	18347.520	546.3561	23.3735
7/16	83.0560	698.9414	18468.254	548.9486	23.4289
1/2	83.2524	702.25	18609.625	551.5471	23.4843
9/16	83 4487	705.5664	18751.607	554.1519	23.5397
5/8	83.6451	708.8906	18874.212	556.7627	23.5951
11/16	83.8414	712.2226	19007.440	559.3797	23.6505
3/4	84.0378	715.5625	19141.296	562.0027	23.7068
13/16	84.2341	718.9101	19275.767	564.6320	23.7613
7/8	84.4305	722.2656	19410.888	567.2674	23.8166
15/16	84.6268	725.6289	19546.628	569.4090	23.8721

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
27 *in.*	84.8232	729	19683	572.5566	23.9274
1/16	85 0195	732.3789	19820.003	575.2104	23.9828
1/8	85.2159	735.7656	19957.642	577.8703	24.0382
3/16	85.4122	739.1601	20058.957	580.5364	24.0936
1/4	85.6086	742.5625	20234.828	583.2085	24.1490
5/16	85.8049	745.9726	20374.376	585.8869	24.2044
3/8	86.0013	749.3906	20514.567	588.5714	24.2598
7/16	86.1976	752.8164	20655.399	591.2620	24.3192
1/2	86.3940	756.25	20796.875	593.9587	24.3705
9/16	86.5903	759.6914	20942.994	596.6616	24.4269
5/8	86.7867	763 1406	21081.759	599.3706	24.4813
11/16	86.9830	766.5976	21225.171	602.0858	24.5067
3/4	87.1794	770.0625	21369.234	604 8070	24.5921
13/16	87.3757	773.5351	21514.044	607.5345	24.6475
7/8	87.5721	777.0156	21659.309	610.2680	24.7029
15/16	87.7684	780.5039	21805.327	613.0078	24.7583
28 *in.*	87.9648	784	21952	615.7536	24.8136
1/16	88.1611	787.5039	22099.328	618.5051	24 8690
1/8	88.3575	791.0156	22247.313	621.2636	24.9244
3/16	88.5538	794.5351	22395.958	624.0279	24.9797
1/4	88 7502	798.0625	22545.265	626.7982	25.0351
5/16	88.9465	801.5976	22695.231	629.5748	25.0905
3/8	89 1429	805.1406	22845.864	632.3574	25.1459
7/16	89.3392	808.6914	22997.161	635.1462	25.2013
1/2	89 5356	812.25	23149.125	637.9411	25.2567
9/16	89.7319	815.8164	23301.755	640.7422	25.3121
5/8	89.9283	819.3906	23455.056	643.5494	25.3675
11/16	90.1246	822.9726	23609.026	646.3627	25.4229
3/4	90.3210	826 5625	23763.671	649.1821	25.4783
13/16	90.5173	830.1601	23919.007	652.0078	25.5337
7/8	90.7137	833.7656	24074.981	654.8395	25.5891
15/16	90.9100	837.3789	24231.651	657.6774	25.6446
29 *in.*	91.1064	841	24389	660.5214	25.6998
1/16	91.3027	844.6289	24547.027	663.3716	25.7524
1/8	91.4991	848.2656	24705.735	666.2278	25.8106
3/16	91.6954	851.9101	24865.126	669.0902	25.8660
1/4	91.8918	855.5625	25025.203	671.9587	25.9214
5/16	92.0081	859.2226	25195.962	674.8335	26.9768
3/8	92.2845	862.8906	25347.411	677.7143	26.0325
7/16	92.4808	866.5664	25519.548	680.6013	26.0876
1/2	92.6772	870.25	25672.375	683.4943	26.1429
9/16	92.8735	873 9414	25835.892	686.3936	26 1983
5/8	93 0699	877.6406	26000.102	689.2989	26.2537
11/16	93.2662	881.3476	26165.006	692.2104	26.3091
3/4	93.4626	885.0625	26330.609	695.1280	26 3645
13/16	93.6589	888.7851	26496.905	698.0518	26.4799
7/8	93.8553	892.5156	26663.903	700.9817	26.4783
15/16	94.0516	896.2539	26831.521	703.9178	26.5307

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
30 *in.*	94.2480	900	27000	706.8600	26.5860
1/16	94.4443	903.7539	27249.101	709.8083	26.6413
1/8	94.6407	907.5156	27338.907	712.7627	26.6967
3/16	94.8370	911.2851	27463.846	715.7233	26.7521
1/4	95.0334	915.0625	27680.640	718.6900	26.8075
5/16	95.2297	918.8476	27852.567	721.6629	26.8629
3/8	95.4261	922.6406	28025.208	724.6419	26.9183
7/16	95.6224	926.4414	28198.561	727.6271	26.9737
1/2	95.8188	930.25	28372.625	730.6183	27.0291
9/16	96.0151	934.0664	28547.504	733.6158	27.0844
5/8	96.2115	937.8906	28722.899	736.6193	27.1398
11/16	96.4078	941.7226	28899.122	739.6290	27.1952
3/4	96.6042	945.5625	29076.046	742.6447	27.2506
13/16	96.8005	949.4101	29253.698	745 6667	27.3060
7/8	96.9969	953.2656	29432.075	748.6948	27.3614
15/16	97.1932	957.1289	29606.975	751.7291	27.4168
31 *in.*	97.3896	961	29791	754.7694	27.4722
1/16	97.5859	964.8789	29979.550	757.8159	27.5275
1/8	97.7823	968.7656	30152.829	760.8685	27.5829
3/16	97.9786	972.6601	30296.203	763.9273	27.6383
1/4	98.1750	976.5625	30517.578	766.9921	27.6937
5/16	98.3713	980.4726	30701.048	770.0632	27.7491
3/8	98.5677	984.3906	30885.255	773.1404	27.8045
7/16	98.7648	988.3164	30946.712	776.2237	27.8599
1/2	98.9684	992.25	31255.875	779.3131	27.9153
9/16	99.1567	996.1914	31442.191	782.4087	27.9706
5/8	99.3531	1000.140	31629.446	785.5104	28.0260
11/16	99.5494	1004.097	31817.542	788.6183	28.0814
3/4	99.7458	1008.062	32005 984	791.7322	28.1368
13/16	99 9421	1012 035	32195.366	794.8524	28.1922
7/8	100.1385	1016.015	32385.497	797.9786	28.2476
15/16	100.3348	1020.003	32576.375	801.1111	28.3030
32 *in.*	100.5312	1024	32768	804.2496	28.3584
1/16	100.7275	1028.003	32960.375	807.3943	28.4137
1/8	100.9240	1032.015	33153.501	810.5450	28.4691
3/16	101.1202	1036.035	33295.578	813.7020	28.5245
1/4	101.3166	1040.062	33542.015	816.8650	28.5799
5/16	101.5130	1044.097	33737.403	820.0343	28.6352
3/8	101.7093	1048 840	33956.314	823.2096	28.6912
7/16	101.9056	1052.191	34130.258	826.3911	28.7466
1/2	102.1020	1056.25	34328.125	829.5787	28.8015
9/16	102.2983	1060.316	34526.552	832.7725	28.8568
5/8	102.4947	1064.390	34725.743	835.9724	28.9122
11/16	102.6910	1068.472	34925.698	839.1784	28.9676
3/4	102.8874	1072.562	35026.421	842.3905	29.0230
13/16	103.0837	1076.660	35327.909	845.6089	29 0784
7/8	103.2801	1080 765	35530.169	848.8333	29.1338
15/16	103.4764	1084.878	35733.198	852.0639	29.1892

Dia. or Rost.	Circum.	Square.	Cube.	Area.	Side of = square.
33 *in.*	103 6728	1089	35937	855.3006	29.2446
1/16	103.8691	1093.129	36141.577	858.5436	29.2999
1/8	104.0655	1097.265	36354.928	861.7924	29.3553
3/16	104.2618	1101.410	36553.144	865.0475	29.4107
1/4	104.4582	1105.562	36759.944	868.3087	29.4661
5/16	104.6545	1109.722	36967.614	871.5760	29.5215
3/8	104 8509	1113.890	37256.088	874.8497	29.5769
7/16	105 0472	1118.066	37385.332	878.1290	29.6323
1/2	105.2436	1122.25	37595.375	881.4151	29.6877
9/16	105.4399	1126.441	37806.176	884.7070	29.7431
5/8	105.6363	1130.640	38017.784	888.0051	29.7985
11/16	105.8326	1134.847	38230.158	891.3090	29.8539
3/4	106 0290	1139.062	38443.352	894.6196	29.9092
13/16	106.2253	1143.285	38657.324	897.9360	29.9646
7/8	106 4217	1147.515	38872.088	901.2587	30.0200
15/16	106.6180	1151.754	39087.651	904.5875	30.0754
34 *in.*	106 8144	1156	39304	907.9224	30.1308
1/16	107.0107	1160.254	39521.152	911.2645	30.1862
1/8	107.2071	1164.515	39738.288	914.6105	30.2416
3/16	107.4034	1168.785	39957.837	917.9640	30.2970
1/4	107 5998	1173.062	40177.384	921.3232	30.3523
5/16	107.7961	1177.347	40397.719	924.6883	30.4077
3/8	107 9925	1181.640	40618.888	928.0605	30.4631
7/16	108 1888	1185.941	40840.843	931.4380	30.5185
1/2	108.3852	1190.25	41063.625	934.8223	30.5739
9/16	108 5815	1194.566	41287.187	938.2121	30.6293
5/8	108 7779	1198.890	41511.576	941.6087	30.6847
11/16	108 9742	1203.222	41736.763	945.0110	30.7400
3/4	109 1706	1207.562	41962.792	948.4195	30.7954
13/16	109.3669	1211.910	42189.617	951.8341	30.8508
7/8	109 5633	1216.265	42417.256	955.2550	30.9062
15/16	109.7596	1220.629	42695.725	958.6820	30.9616
35 *in.*	109.9560	1225	42875	962.1150	31.0170
1/16	110.1523	1229.379	43105.081	965.5542	31.0724
1/8	110.3487	1233.765	43352.016	968.9995	31.1278
3/16	110.5450	1238.160	43567.755	972.4510	31.1831
1/4	110.7414	1242.562	43800.320	975.9085	31.2386
5/16	110.9377	1246.968	44033.557	979.3686	31.2939
3/8	111.1341	1251.390	44267.944	982.8422	31.3493
7/16	111.3304	1255.816	44502.979	986.3180	31.4047
1/2	111.5268	1260.25	44738.875	989.8003	31.4601
9/16	111.7231	1264.591	44972.017	993.2097	31.5155
5/8	111.9195	1269.140	45213.120	996.7830	31.5709
11/16	112.1158	1273.597	45451.493	1000.3472	31.6263
3/4	112.3122	1278.062	45690.728	1003.7962	31.6817
13/16	112.5086	1282.535	45930.784	1007.3030	31.7370
7/8	112.7049	1287.015	46171.680	1010.8220	31.7924
15/16	112.9012	1291.504	46413.425	1014.3472	31.8478

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square
36 in.	113.0976	1296	46656	1017.8784	31.9032
1/16	113.2939	1306.503	47115.796	1021.4158	31.9585
1/8	113.4903	1308.015	47252.063	1024.9592	32.0139
3/16	113.6866	1309.535	47388.001	1028.5089	32.0693
1/4	113 8830	1314.062	47634.765	1032.0646	32.1247
5/16	114 0793	1318.597	47881.565	1035.6266	32.1801
3/8	114.2757	1323.140	48129.239	1039.1946	32.2355
7/16	114.4720	1327.691	48377.795	1042.7913	32.2909
1/2	114.6684	1332.25	48627.125	1046.3941	32.3463
9/16	114 8647	1336.816	48877.349	1049.9581	32.4016
5/8	115.0611	1341.390	49128.430	1053.5281	32.4570
11/16	115.2572	1345.972	49380.360	1057.1269	32.5124
3/4	115.4538	1350.562	49633.171	1060.7317	32.5678
13/16	115.6501	1355.160	49886.831	1064.3428	32.6232
7/8	115.8465	1359.765	50141.356	1067.9599	32.6786
15/16	116.0428	1364.378	50396.745	1071.5832	32.7340
37 in.	116.2392	1369	50653	1075.2126	32.7894
1/16	116.4355	1373.628	51010.121	1078.8482	32.8447
1/8	116.6319	1378.265	51168.110	1082.4898	32.9001
3/16	116.8282	1382.910	51426.969	1086.1376	32.9555
1/4	117.0246	1387.562	51686.703	1089.7915	33.0109
5/16	117.2209	1392.222	52447.305	1093.4517	33.0663
3/8	117.4173	1396.890	52208.786	1097.1179	33.0217
7/16	117.6136	1401 566	52471.142	1100.7903	33.1771
1/2	117.8100	1406.25	52734.375	1104.4687	33.2325
9/16	118.0063	1410.941	52998.497	1108.1534	33.2878
5/8	118.2027	1415.640	53263.477	1111.8441	33.3432
11/16	118.3990	1420.347	53517.892	1115.5410	33.3986
3/4	118.5954	1425.062	53796.109	1119.2440	33.4540
13/16	118.7917	1429.785	54063 629	1122.9532	33 5094
7/8	118.9881	1434.515	54332.278	1126.6685	33.5648
15/16	119.1844	1439.253	54601.694	1130.3900	33.6202
38 in.	119.3808	1444	54872	1134.1176	33.6756
1/16	119.5771	1448.753	55143 195	1137.8513	33.7309
1/8	119.7735	1453.515	55415.282	1141.5911	33.7863
3/16	119.9698	1458.285	55687 252	1145.3371	33.8417
1/4	120.1662	1463.062	55962.140	1149.0892	33.8971
5/16	120.3625	1467.847	56236.915	1152.8475	33.9525
3/8	120 5589	1472.640	56512.583	1156.6119	34.0079
7/16	120.7552	1477.441	56789.213	1160.3825	34.0633
1/2	120.9516	1482.25	57066 625	1164.1591	34.1187
9/16	121.1479	1487.066	57244 998	1167.9420	34.1740
5/8	121.3443	1491.890	57624.274	1171.7309	34.2294
11/16	121.5406	1496.722	57904.455	1175.5260	34.2848
3/4	121.7370	1501.562	58185.546	1179 3271	34.3402
13/16	121.9333	1506.410	58467.542	1183.1345	34.3956
7/8	122.1297	1511.265	58750.450	1186.9480	34.4510
15/16	122.3260	1516.128	59034.251	1190.7677	34.5064

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
39 *in.*	122.5224	1521	59319	1194.5934	34.5618
1/16	122.7187	1525.878	59604.445	1198.4253	34.6171
1/8	122.9151	1530.765	59891.204	1202 2633	34.6725
3/16	123 1114	1535.660	60178.680	1206.1075	34.7279
1/4	123.3078	1540.562	60466.078	1209.9577	34.7833
5/16	123.5041	1545.472	60756 391	1213 8142	34.8387
3/8	123.7005	1550.390	61046.629	1217.6768	34 8941
7/16	123.8968	1555.316	61337.798	1221.5455	34.9495
1/2	124.0932	1560.25	61629.875	1225.4203	35.0049
9/16	124.2895	1565.191	61922 884	1229.3013	35.0602
5/8	124.4859	1570.140	62216.822	1233.1884	35.1156
11/16	124.6822	1575.097	62511.686	1237.0817	35.1710
3/4	124.8786	1580.062	62807.484	1240.9810	35.2264
13/16	125.0749	1585.035	63304.209	1244.8866	35.2818
7/8	125.2713	1590.015	63401.872	1248.7982	35.3372
15/16	125.4676	1595.003	63700.468	1252.7161	35.3926
40 *in.*	125.6640	1600	64000	1256.6400	35.4480
1/16	125.8603	1605.003	64300.468	1260.5701	35.5033
1/8	126.0567	1610.015	64601 875	1264.5062	35.5587
3/16	126.2530	1615.035	64894.223	1268.4486	35.6141
1/4	126.4494	1620.062	65207.515	1272.3970	35.6695
5/16	126.6457	1625.097	65511.747	1276.3517	35.7249
3/8	126.8421	1630.140	65816.926	1280.3124	35.7803
7/16	127.0384	1635 191	66123.052	1284.2793	35.8357
1/2	127.2348	1640 25	66430.125	1288.2523	35.8911
9/16	127.4311	1645.316	66738.146	1292.2315	35.9464
5/8	127.6275	1650.390	67047.110	1296.2168	36.0018
11/16	127.8238	1655.472	67357.041	1300.2082	36.0572
3/4	128.0202	1660.562	67667.925	1304.2057	36.1126
13/16	128.2165	1665.660	67971.590	1308.2095	36.1680
7/8	128.4129	1670.765	68292.539	1312.2193	36.2234
15/16	128.6092	1675.878	68706.292	1316.2353	36.2788
41 *in.*	128.8056	1681	68921	1320.2574	36.3342
1/16	129.0019	1686.128	69236.667	1324.2857	36.3895
1/8	129.1983	1691.265	69553.297	1328.3200	36.4449
3/16	129.3946	1696.410	69870.890	1332.3605	36.5003
1/4	129.5910	1701.562	70189.453	1336.4071	36.5557
5/16	129.7873	1706.722	70508.977	1340.4600	36.6111
3/8	129.9837	1711.890	70829.473	1344.5189	36.6665
7/16	130.1800	1717.066	71150.938	1348.5840	36.7219
1/2	130.3764	1722.25	71473.375	1352.6551	36.7773
9/16	130.5727	1727.441	71703.482	1356.7325	36.8326
5/8	130.7691	1732.640	72121.164	1360.8159	36.8880
11/16	130.9654	1737.847	72444.541	1364.9055	36.9434
3/4	131.1618	1743.062	72772.859	1369.0012	36.9988
13/16	131.3581	1748.285	73100.170	1373.1031	37.0542
7/8	131 5545	1753.515	73428.465	1377.2111	37.1096
15/16	131.7508	1758.753	73757.791	1381.3253	37.1650

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
42 *in.*	131.9472	1764	74088	1385.4456	37.2204
1/16	132.1435	1769.253	74419.242	1389.5720	37.2757
1/8	132.3399	1774.515	74751.469	1393.7045	37.3311
3/16	132.5362	1779.785	75084.683	1397.8432	37.3865
1/4	132.7326	1785.062	75418.890	1401.9880	37.4419
5/16	132.9289	1790.347	75711.770	1406.1390	37.4973
3/8	133.1253	1795.640	76090.270	1410.2961	37.5527
7/16	133.3216	1800.941	76426.450	1414.4594	37.6081
1/2	133.5180	1806.25	76765.625	1418.6287	37.6635
9/16	133.7143	1811.566	77304.794	1422.8043	37.7188
5/8	133.9107	1816.890	77444.961	1426.9859	37.7742
11/16	134.1070	1822.222	77786.127	1431.1737	37.8296
3/4	134.3034	1827.562	78128.296	1435.3675	37.8850
13/16	134.4997	1832.910	78471.463	1439.5676	37.9404
7/8	134.6961	1838.265	78815.637	1443.7738	37.9958
15/16	134.8924	1843.628	79160.815	1447.9862	38.0512
43 *in.*	135 0888	1849	79507	1452.2046	38.1066
1/16	135.2851	1854.378	79854.191	1456.4292	38.1619
1/8	135.4815	1859.765	80202.391	1460.6599	38.2173
3/16	135.6778	1865.160	80551.601	1464.8968	38.2727
1/4	135.8742	1870.562	80901.828	1469.1397	38.3281
5/16	136.0705	1875.972	81253.063	1473.3839	38.3835
3/8	136.2669	1881.390	81605.317	1477.6342	38.4389
7/16	136.4632	1886.816	81958.587	1481.9006	38.4943
1/2	136.6596	1892.25	82312.875	1486.1731	38.5497
9/16	136.8559	1897.691	82668.181	1490.4468	38.6050
5/8	137.0523	1903.140	83024.508	1494.7266	38.6604
11/16	137.2486	1908.597	83382.857	1499.0126	38.7158
3/4	137.4450	1914.062	83740.234	1503.3046	38.7712
13/16	137.6413	1919.535	84099.631	1507.6029	38.8266
7/8	137.8377	1925.015	84460.059	1511.9072	38.8820
15/16	138.0340	1930.503	84831.515	1516.2178	38.9374
44 *in.*	138.2304	1936	85184	1520.5344	38.9928
1/16	138.4267	1941.503	85547.515	1524.8572	39.0481
1/8	138.6231	1947.015	85912.063	1529.1860	39.1035
3/16	138.8194	1952.535	86278.844	1533.5211	39.1589
1/4	139.0158	1958.062	86644.265	1537.8622	39.2143
5/16	139.2121	1963.597	87011.918	1542.2046	39.2697
3/8	139.4085	1969.140	87380.614	1546.5530	39.3251
7/16	139.6048	1974.691	87740.259	1550.9176	39.3805
1/2	139.8012	1980.25	88121.125	1555.2883	39.4359
9/16	139.9975	1985.816	88492.943	1559.6602	39.4912
5/8	140.1939	1991.390	88865.805	1564.0382	39.5466
11/16	140.3902	1996.972	89239.713	1568.4223	39.6020
3/4	140.5866	2002.562	89614.652	1572.8125	39.6574
13/16	140.7829	2008.160	89990.674	1577.2090	39.7128
7/8	140.9793	2013.765	90367.731	1581.6115	39.7682
15/16	141.1756	2019.378	90745.839	1586.0203	39.8236

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of =square.
45 in.	141.3720	2025	91125	1590.4350	39.8790
1/16	141.5683	2030.628	91515.214	1594.4560	39.9343
1/8	141.7647	2036.265	91886.485	1599.2830	39.9897
3/16	141.9610	2041.910	92268.812	1603.7162	40.0451
1/4	142.1574	2047.562	92652.203	1608.1555	40.1005
5/16	142.3537	2053.222	93036.640	1612.5961	40.1559
3/8	142.5501	2058.890	93422.161	1617.0427	40.2113
7/16	142.7464	2064.566	93808.735	1621.5055	40.2667
1/2	142 9428	2070.25	94196.375	1625.9743	40.3221
9/16	143.1391	2075.941	94585.080	1630.4444	40.3774
5/8	143.3355	2081.640	94974.852	1634.9205	40.4328
11/16	143.5318	2087.347	95363.694	1639.4028	40.4882
3/4	143.7282	2093.062	95757.609	1643.8912	40.5436
13/16	143.9245	2098.785	96149.592	1648.3858	40.5990
7/8	144.1209	2104.515	96544.653	1652.8865	40.6544
15/16	144.3172	2110.253	97239.788	1657.3934	40.7098
46 in.	144.5136	2116	97336	1661.9064	40.7652
1/16	144.7099	2121.753	97733.289	1666.4255	40.8025
1/8	144.9063	2127.515	98131.657	1670.9507	40.8759
3/16	145.1026	2133.285	98231.103	1675.4821	40.9313
1/4	145.2990	2139.062	98931.640	1680.0196	40.9867
5/16	145.4953	2144.847	99333.254	1684.5583	41.0421
3/8	145.6917	2150.640	99735.957	1689.1031	41.0975
7/16	145.8880	2156.441	100139.447	1693.6641	41.1529
1/2	146.0844	2162.25	100544.625	1698.2311	41.2083
9/16	146.2807	2168.066	100950.601	1702.7994	41.2636
5/8	146.4771	2173 890	101357.649	1707.3737	41.3190
11/16	146.6734	2179.722	101765.778	1711.9542	41.3744
3/4	146.8698	2185.562	102175.046	1716.5407	41.4298
13/16	147.0661	2191.410	102185.385	1721.1335	41.4852
7/8	147.2625	2197.265	102996.825	1725.7324	41.5406
15/16	147.4588	2203.128	103413.900	1730.3375	41.5960
47 in.	147.6552	2209	103823	1734.9486	41.6514
1/16	147.8515	2214.878	104237.738	1739.5659	41.7067
1/8	148.0479	2220.765	104653.579	1744.1893	41.7621
3/16	148.2442	2226.660	105070.523	1748.8189	41.8175
1/4	148.4406	2232.562	105488.578	1753.4545	41.8729
5/16	148.6369	2238.472	105907.734	1758.0914	41.9283
3/8	148.8333	2244.390	106328.004	1762.7344	41.9837
7/16	149.0296	2250.316	106749.384	1767.3935	42.0391
1/2	149.2260	2256.25	107171.875	1772.0587	42.0945
9/16	149.4223	2262.191	107593.478	1776.7251	42.1498
5/8	149.6187	2268.140	108020.196	1781.3976	42.2052
11/16	149.8150	2274.097	108446 029	1786.0763	42.2606
3/4	150.0114	2280.062	108872.984	1790.7610	42 3160
13/16	150.2077	2286.035	109310.753	1795.4520	42.3714
7/8	150.4041	2292.015	109730.246	1800.1490	42.4268
15/16	150.6004	2298.003	110160.561	1804.8523	42.4822

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
48 *in.*	150.7968	2304	110592	1809.5616	42.5376
1/16	150.9931	2310.004	111024.610	1814.2551	42.5929
1/8	151.1895	2316.015	111458.250	1818.9986	42.6483
3/16	151.3858	2322.035	111993.066	1823.7264	42.7037
1/4	151.5822	2328.062	112329.015	1828.4602	42.7591
5/16	151.7785	2334.097	112855.090	1833.1953	42.8145
3/8	151.9749	2340.140	113204.301	1837.9364	42.8699
7/16	152.1712	2346.191	113643.645	1842.6937	42.9253
1/2	152.3676	2352.25	114084.125	1847.4571	42.9807
9/16	152.5639	2358.316	114725.740	1852.2167	43.0361
5/8	152.7603	2364.390	114968.493	1856.9924	43.0915
11/16	152.9566	2370.472	115412.384	1861.7892	43.1468
3/4	153.1530	2376.562	115857.421	1868.5521	43.2022
13/16	153.3493	2382.660	116303.596	1871.3413	43.2576
7/8	153.5457	2388.765	116750.918	1876.1365	43.3130
15/16	153.7420	2394.878	117199.386	1880.9379	43.3684
49 *in.*	153.9384	2401	117649	1885.7454	43.4238
1/16	154.1347	2407.129	118099.810	1890.5591	43.4791
1/8	154.3311	2413.265	118551.672	1895.3788	43.5345
3/16	154.5274	2419.410	119004.734	1900.2047	43.5899
1/4	154.7238	2425.562	119458.953	1905.0367	43.6453
5/16	154.9201	2431.722	119914.320	1909.8700	43.7007
3/8	155.1165	2437.890	120370.848	1914.7093	43.7561
7/16	155.3128	2444.066	120828.532	1919.5648	43.8115
1/2	155.5092	2450.25	121287.375	1924.4263	43.8669
9/16	155.7055	2456.441	121747.376	1929.2891	43.9223
5/8	155.9019	2462.640	122208.539	1934.1579	43.9777
11/16	156.0982	2468.847	122671.264	1939.0329	44.0330
3/4	156.2946	2475.062	123134.359	1943.9140	44.0884
13/16	156.4909	2481.285	123599.014	1948.8013	44.1438
7/8	156.6873	2487.515	124064.336	1953.6947	44.1992
15/16	156.8836	2493.753	124531.835	1958.0943	44.2546
50 *in.*	157.0800	2500	125000	1963.5000	44.3100
1/16	157.2763	2506.254	125469.386	1968.4118	44.3653
1/8	157.4727	2512.515	125939.844	1973.3297	44.4207
3/16	157.6690	2518.785	126411.527	1978.2525	44.4761
1/4	157.8654	2525.062	126884.390	1983.1840	44.5315
5/16	158.0617	2531.347	127358.426	1988.6154	44.5869
3/8	158.2581	2537.640	127833.645	1993.0529	44.6423
7/16	153.4544	2543.941	128310.004	1998.0066	44.6977
1/2	158.6508	2550.25	128787.625	2002.9663	44.7531
9/16	158.8471	2556.566	129266.388	2007.9273	44.8085
5/8	159.0435	2562.890	129746.336	2012.8943	44.8639
11/16	159.2398	2569.222	130327.469	2017.8675	44.9192
3/4	159.4362	2575.562	130709.797	2022.8467	44.9746
13/16	159.6325	2581.910	131193.306	2027.8172	45.0300
7/8	159.8289	2588.265	131678.012	2032.8238	45.0854
15/16	160.0252	2594.628	132163.909	2037.8216	45.1408

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
51 *in.*	160.2216	2601	132651	2042.8254	45.1962
1/16	160.4179	2607.379	133139.336	2047.8354	45.2515
1/8	160.6143	2613.765	133628.766	2052.8515	45.3069
3/16	160.8106	2620.160	134119.445	2057 8798	45.3623
1/4	161.0070	2626.562	134611.328	2062.9021	45.4177
5/16	161.2033	2632.972	135104.406	2067.9317	45.4731
3/8	161.3997	2639.390	135598.692	2072.9674	45.5285
7/16	161.5960	2645.816	136094.181	2078.0293	45 5839
1/2	161.7924	2652.25	136590.875	2083.0771	45.6393
9/16	161.9887	2658.691	137088.775	2088.1362	45.6947
5/8	162.1851	2665.140	137587.883	2093.2014	45.7501
11/16	162.3814	2671.597	138088.220	2098.2678	45 8054
3/4	162.5778	2678.062	138589.734	2103.3502	45.8608
13/16	162 7741	2684.535	139092.474	2108.4339	45.9162
7/8	162.9705	2691.015	139596.434	2113.5236	45.9716
15/16	163.1668	2697.503	140101.557	2118.1196	46.0270
52 *in.*	163.3632	2704	140608	2123 7216	46.0824
1/16	163.5595	2710.504	141115.661	2128.8298	46.1377
1/8	163.7559	2717.015	141624.438	2133.9440	46.1931
3/16	163.9522	2723.535	142134.389	2139.0645	46.2485
1/4	164.1486	2730.062	142645.765	2144.1910	46.3039
5/16	164.3449	2736.597	143158.251	2149.3238	46.3593
3/8	164 5413	2743.140	143671.989	2154.4626	46.4147
7/16	164.7376	2749.691	144186.942	2159.6076	46 4701
1/2	164.9340	2756.25	144703.125	2164.7587	46.5255
9/16	165.1303	2762.816	145219.537	2169.9160	46.5809
5/8	165.3267	2769.390	145739.180	2175.0794	46.6363
11/16	165.5230	2775.972	146606.052	2180.2489	46.6916
3/4	165.7194	2782.562	146780.172	2185.4245	46.7470
13/16	165.9157	2789.160	146953.872	2190.6064	46.8024
7/8	166.1121	2795.765	147826.106	2195.7943	46.8578
15/16	166.3084	2802.378	148350.893	2200.9884	46.9132
53 *in.*	166.5048	2809	148877	2206.1886	46 9686
1/16	166.7011	2815.629	149404.361	2211.3950	47.0239
1/8	166.8975	2822.265	149932.860	2216.6074	47.0793
3/16	167.0938	2828.910	150462.655	2221.8260	47.1347
1/4	167.2902	2835.562	150993.703	2227.0507	47.1901
5/16	167.4865	2842.222	151525.992	2232.2817	47.2455
3/8	167.6829	2848.890	152059.535	2237.5187	47.3009
7/16	167.8792	2855.566	152594.329	2242.7619	47.3563
1/2	168.0756	2862.25	153130.375	2248.0111	47.4117
9/16	168.2719	2868.941	153667.673	2253.2666	47.4671
5/8	168.4683	2875.640	154206.227	2258.5281	47.5225
11/16	168.6646	2882.347	154746.036	2263.7908	47.5778
3/4	168.8610	2889.062	155287.109	2269.0696	47.6332
13/16	169.0573	2895.785	155829.336	2274.3496	47.6886
7/8	169.2537	2902.515	156373.028	2279.6357	47.7440
15/16	169.4500	2909.253	156917.882	2284.9280	47.7994

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
54 in.	169 6464	2916	157464	2290.2264	47.8548
1/16	169.8427	2922.754	158011.436	2295.5309	47.9101
1/8	170.0391	2929.515	158560.032	2300.8415	47.9655
3/16	170.2354	2936.285	159109.948	2306.1583	48.0209
1/4	170.4318	2943.062	159661.140	2311.4812	48.0763
5/16	170.6281	2949.847	160213.597	2316.8163	48.1317
3/8	170 8245	2956.640	160767.332	2322.1455	48.1871
7/16	171.0208	2963.441	161322.541	2327.4819	48.2425
1/2	171.2172	2970.25	161878.625	2332.8343	48.2979
9/16	171.4135	2977.066	162436.185	2338.1880	48.3533
5/8	171.6099	2983.890	162995.024	2343.547,	48.4087
11/16	171.8062	2990.722	163854 242	2348 9636	48.4640
3/4	172.0026	2997.562	164116 547	2354.2855	48.5194
13/16	172.1989	3004.410	164679.328	2359 6637	48.5748
7/8	172 3953	3011.265	165243.199	2365.0480	48.6302
15/16	172.5916	3018.128	165808.456	2370.4385	48.6856
55 in	172 7880	3025	166375	2375.8350	48.7410
1/16	172.9843	3031.879	166942 886	2381.2382	48.7963
1/8	173 1807	3038.765	167511.953	2386.6465	48.8517
3/16	173.3770	3045.660	168295.866	2392.0515	48.9071
1/4	173.5734	3052.562	168654.078	2397.4825	48.9625
5/16	173 7697	3059.472	169225.578	2402.9098	49.0179
3/8	173.9661	3066.390	169801.379	2408.3432	49.0733
7/16	174.1624	3073.316	170169.779	2413.7777	49.1287
1/2	174.3588	3080.25	170953.875	2419.2283	49.1841
9/16	174 5551	3087.191	171532.072	2424 7026	49.2395
5/8	174.7515	3094.140	172111.570	2430.1830	49.2949
11/16	174.9478	3101.097	172692.372	2435.6246	49.3502
3/4	175 1442	3108.062	173274.484	2441.0722	49.4056
13/16	175.3405	3115.035	173856.496	2446.5486	49.4610
7/8	175 5369	3122.015	174442.621	2452.0310	49.5164
15/16	175.7332	3129.003	175028.655	2457.0197	49.5718
56 in.	175 9296	3136	175616	2463.0144	49.6272
1/16	176.1259	3143.004	176204.712	2468.5153	49.6825
1/8	176.3223	3150.015	176794.625	2474.0222	49.7379
3/16	176.5186	3157.085	177385.909	2479.5354	49.7933
1/4	176.7150	3164.062	177978.515	2485.0546	49.8487
5/16	176.9113	3171.097	178572 433	2490.5351	49.9041
3/8	177.1077	3178.140	179167 676	2496.1116	49.9595
7/16	177.3040	3185.191	179764.239	2501.6493	50.0149
1/2	177.5004	3192.25	180362.125	2507.1931	50.0703
9/16	177.6967	3199.316	180961.343	2512.7431	50.1257
5/8	177.8931	3206.390	181561.867	2518.2992	50.1811
11/16	178.0894	3213.472	182163.728	2523.8614	50.2364
3/4	178.2858	3220.562	182766 921	2529.4297	50.2918
13/16	178.4821	3227.660	183371.441	2535.0043	50.3472
7/8	178.6785	3234.765	183977.293	2540.5849	50.4026
15/16	178.8748	3241.878	184384.489	2546.1717	50.4580

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
57 in.	179.0712	3249	185193	2551.7646	50.5134
1/16	179.2675	3256.129	185802.912	2557.3637	50.5687
1/8	179.4639	3263.265	186414.047	2562.9688	50.6241
3/16	179.6602	3270.410	187026.577	2568.5801	50.6795
1/4	179.8566	3277.562	187640.453	2574.1975	50.7349
5/16	180.0529	3284.722	188255.664	2579.8212	50.7903
3/8	180.2493	3291.890	188872.223	2585.4509	50.8457
7/16	180.4456	3299.066	189490.126	2591.0869	50.9011
1/2	180.6420	3306.25	190109.375	2596.7287	50.9565
9/16	180.8383	3313.441	190729.970	2602.3769	51.0119
5/8	181.0347	3320.640	191351.914	2608.0311	51.0673
11/16	181.2310	3327.847	191985.008	2613.6942	51.1226
3/4	181.4274	3335.062	192599.859	2619.3580	51.1780
13/16	181.6237	3342.285	193225.857	2625.0307	51.2334
7/8	181.8201	3349.515	193853.215	2630.7095	51.2888
15/16	182.0164	3356.753	194471.829	2636.3945	51.3442
58 in.	182.2128	3364	195112	2642.0856	51.3996
1/16	182.4091	3371.254	195743.487	2647.7328	51.4549
1/8	182.6055	3378.515	196376.219	2653.4861	51.5103
3/16	182.8018	3385.785	197010.370	2659.9565	51.5657
1/4	182.9982	3393.062	197645.899	2664.9112	51.6211
5/16	183.1945	3400.347	198282.869	2670.6330	51.6765
3/8	183.3909	3407.640	198921.020	2676.3609	51.7319
7/16	183.5872	3414.941	199561.638	2682.0950	51.7873
1/2	183.7836	3422.25	200201.625	2687.8351	51.8427
9/16	183.9799	3429.566	200743.982	2693.5814	51.8981
5/8	184.1763	3436.890	201487.711	2699.3338	51.9535
11/16	184.3726	3444.222	202132.813	2705.0924	52.0088
3/4	184.5690	3451.562	202779.296	2710.8571	52.0642
13/16	184.7653	3458.910	203027.158	2716.6280	52.1196
7/8	184.9617	3466.265	204076.387	2722.4050	52.1750
15/16	185.1580	3473.628	204729.005	2728.1882	52.2304
59 in.	185.3544	3481	205379	2733.9774	52.2858
1/16	185.5507	3488.379	206032.437	2739.7728	52.3411
1/8	185.7471	3495 765	206687.141	2745.5743	52.3965
3/16	185.9434	3503.160	207343.288	2751.8820	52.4519
1/4	186.1398	3510.562	208000.828	2757.1957	52.5073
5/16	186.3361	3517.972	208659.649	2763.0157	52.5627
3/8	186.5325	3525.390	209320.066	2768.8418	52.6181
7/16	186.7288	3532.816	209981.374	2774.6745	52.6735
1/2	186.9252	3540.25	210644.875	2780.5123	52.7289
9/16	187.1215	3547.691	211309.369	2786.3568	52.7843
5/8	187.3179	3555.140	212975.258	2792.2074	52.8397
11/16	187.5142	3562.597	212642.544	2798.0642	52.8950
3/4	187.7106	3570.062	213311.234	2803.9270	52.9504
13/16	187.9069	3577.535	213981.318	2809.7461	53.0058
7/8	188.1033	3585.015	214642.809	2815.6712	53 0612
15/16	188.2996	3592.503	215325.702	2821.5526	53.1166

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
60 *in.*	188.4960	3600	216000	2827.4400	53.1720
1/16	188.6923	3607.503	216676.003	2833.3336	53.2274
1/8	188.8887	3615.015	217352.813	2839.2332	53.2828
3/16	189.0850	3622.535	218041.381	2845.1391	53.3381
1/4	189.2814	3630.062	218711.265	2851.0510	53.3935
5/16	189.4777	3637.597	219392.605	2856.9692	53.4489
3/8	189.6741	3645.140	220075.363	2862.8934	53.5043
7/16	189.8704	3652.691	221759.536	2868.8223	53.5597
1/2	189.0668	3660.25	221445.125	2874.7603	53.6151
9/16	190.2631	3667.816	221132.140	2880.7030	53.6705
5/8	190.4595	3675.390	222820.555	2886.6517	53.7259
11/16	190.6558	3682.972	223510.400	2892.6067	53.7813
3/4	190.8522	3690.562	224201.672	2898.5677	53.8367
13/16	191.0485	3698.160	224894.361	2904.5350	53.8920
7/8	191.2449	3705.765	225588.481	2910.5083	53.9474
15/16	191.4412	3713.378	226284.016	2916.4878	54.0028
61 *in.*	191.6376	3721	226981	2922.4734	54.0582
1/16	191.8339	3728.628	227679.402	2928.4652	54.1136
1/8	192.0303	3736 265	228379.235	2934.4630	54.1680
3/16	192.2266	3743.910	229079.699	2940.4670	54.2243
1/4	192.4230	3751.562	229783.203	2946.4771	54.2797
5/16	192.6193	3759.222	230487.336	2952.4938	54.3351
3/8	192.8157	3766.890	231192.911	2958.5159	54.3905
7/16	193.0120	3774.566	231949.923	2964 5445	54.4459
1/2	193.2084	3782.25	232608.375	2970 5791	54.5013
9/16	193 4047	3789.941	233311.067	2976.6200	54.5567
5/8	193.6011	3797.640	234029.602	2982 6669	54.6121
11/16	193.7974	3805.347	234744.380	2988.7200	54.6675
3/4	193.9938	3813.062	235456.609	2994.7792	54.7229
13/16	194.1901	3820.785	236172.279	3000.8423	54.7782
7/8	194.3865	3828.515	236889.403	3006.9161	54.8336
15/16	194.5828	3836.253	237607.976	3017.9938	54.8890
62 *in.*	194.7792	3844	238328	3019.0776	54.9444
1/16	194.9755	3851.753	239050.476	3025.1675	54.9998
1/8	195.1719	3859.515	239772.406	3031.2635	55.0552
3/16	195.3682	3867.285	240496.792	3037.3607	55.1105
1/4	195.5646	3875.062	241222 640	3043.4740	55.1659
5/16	195.7609	3882.847	241948.941	3049.6885	55.2213
3/8	195.9573	3890.640	242678.707	3055.7091	55.2767
7/16	196.1536	3898.441	243408.935	3061.8359	55.3321
1/2	196.3500	3906.25	244140.625	3067.9687	55.3875
9/16	196.5463	3914.066	244873.779	3074.1578	55.4429
5/8	196.7427	3921.890	245608.399	3080 2529	55.4983
11/16	196.9390	3929.722	246344.485	3086.4042	55.5536
3/4	197.1354	3937.562	247082.047	3092.5615	55.6090
13/16	197.3317	3945.410	247821.072	3098.7251	55.6644
7/8	197.5281	3953.265	248561.574	3104.8948	55.7198
15/16	197.7244	3961.128	249309.650	3111.0707	55.7752

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
63 in.	197.9208	3969	250047	3117.2526	55.8306
1/16	198.1171	3976.878	250791 925	3124.4407	55.8850
1/8	198 3135	3984.765	251538.328	3129.6349	55.9414
3/16	198 5098	3992 660	252286.210	3135.8353	55.9967
1/4	198 7062	4000.562	253035.578	3142.0417	56.0521
5/16	198.9025	4008.472	253786.921	3148.7544	56.1075
3/8	199.0989	4016.390	254538.754	3154.4732	56.1629
7/16	199.2952	4024.316	255292.571	3160.7981	56.2183
1/2	199.4916	4032.25	256047.875	3166.9291	56.2737
9/16	199.6879	4040.191	256804.665	3173.1663	56.3291
5/8	199 8843	4048.140	257562.945	3179.4096	56.3845
11/16	200.0806	4056.097	258322 715	3185.6591	56.4398
3/4	200 2770	4064.062	259083.984	3191.9146	56.4952
13/16	200.4733	4072 035	259856.739	3198.1764	56.5506
7/8	200 6697	4080.015	260610 996	3204.4442	56.6060
15/16	200.8660	4088.003	261376.749	3210.7183	56.6614
64 in.	201.0624	4096	262144	3216.9984	56 7168
1/16	201.2587	4104.003	262912 749	3223.2847	56.7721
1/8	201.4551	4112 015	263683 000	3229.5770	56.8276
3/16	201.6514	4120.035	264454.153	3235.8746	56.8829
1/4	201.8478	4128.062	265228 015	3242.1782	56.9383
5/16	202.0441	4136.097	266102 777	3248.4936	56.9537
3/8	202.2405	4144.140	266779 051	3254.8080	57.0491
7/16	202 4368	4152.191	267557 633	3261.1311	57.1045
1/2	202 6332	4160.25	268336.125	3267.4603	57.1599
9/16	202 8295	4168.316	269054.927	3273.7957	57.2153
5/8	203.0259	4176.390	269899.242	3280.1372	57.2707
11/16	203.2222	4184.472	270683.071	3286.4875	57.3261
3/4	203.4186	4192.562	271468.422	3292.8385	57.3815
13/16	203.6149	4200.650	272248.153	3299.1985	57.4368
7/8	203.8113	4208.765	273043.668	3305.5645	57.4922
15/16	204.0076	4216.878	273814.092	3311.9367	57.5476
65 in.	204.2040	4225	274625	3318.3151	57.6030
1/16	204.4003	4233.128	275417.949	3324.7495	57.6584
1/8	204.5917	4241.265	276212.422	3331.0900	57.7138
3/16	204.7930	4249.410	277198.283	3337.9857	57.7691
1/4	204.9894	4257.562	277805.953	3343.8875	57.8245
5/16	205.1857	4265 722	278606 007	3350.2976	57.8799
3/8	205 3821	4273 890	279405 608	3356.7137	57.9353
7/16	205.5784	4282.066	280207.720	3363.1350	57 9907
1/2	205.7748	4290.25	281011.375	3369 5623	58 0461
9/16	205 9711	4298.441	281816.564	3375 9959	58.1015
5/8	206.1675	4306.640	282623.289	3382.4355	58 1569
11/16	206 3638	4314 847	283431.551	3388.8813	58 2122
3/4	206 5602	4323 062	284241 359	3395.3332	58.2676
13/16	206 7565	4331.275	285037.242	3401.7913	58 3230
7/8	206.9529	4339 515	285865 590	3408 2555	58.3784
15/16	207.1492	4347.753	286879.943	3414.7259	58.4338

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
66 *in.*	207.3456	4356	287496	3421.2024	58.4892
1/16	207.5419	4364.253	288313.523	3427.6850	58.5446
1/8	207.7383	4372.515	289132.594	3434.1737	58.5990
3/16	207.9346	4380.785	289953.213	3440.6676	58.6553
1/4	208.1310	4389.062	290775.390	3447.1676	58.7108
5/16	208 3273	4397.347	291592.211	3453.6758	58.7661
3/8	208 5237	4405.640	292424.395	3468.1901	58.8215
7/16	208.7200	4413.941	293251.231	3470.7096	58.8769
1/2	208.9164	4422.25	294079.625	3473.2351	58.9323
9/16	209.1127	4430.566	294899.576	3479.7669	58.9877
5/8	209.3091	4438.890	295741.086	3486.3047	59.0431
11/16	209 5054	4447.222	296574.157	3492.8487	59.0984
3/4	209.7018	4455 562	297408 797	3499.3987	59.1539
13/16	209 8981	4463.900	298744 325	3506.4550	59.2092
7/8	210.0945	4472.265	299082.762	3512 5174	59.2646
15/16	210.2908	4480.628	299922.097	3519.0860	59.3200
67 *in.*	210.4872	4489	300763	3525.6606	59.3754
1/16	210.6835	4497.378	301605.472	3532.2414	59.4308
1/8	210.8799	4505.765	302449.516	3538.8283	59.4862
3/16	211.0762	4514.160	303295.131	3545.4200	59.5415
1/4	211.2726	4522 562	304142.328	3552.0185	59.5969
5/16	211.4689	4530.972	304986.093	3558.6249	59.6523
3/8	211.6653	4539.390	305841.442	3565.2374	59.7077
7/16	211.8616	4547.816	306893.366	3571.8550	59 7631
1/2	212.0580	4556.25	307546.875	3578 4787	59.8185
9/16	212.2543	4564.691	308402.462	3585.1086	59.8739
5/8	212.4507	4573.140	309258.633	3591.7446	59.9293
11/16	212.6470	4581.597	310045.532	3598.8868	59.9847
3/4	212.8434	4590.062	310976.734	3605.0350	60.0401
13/16	213.0397	4598 535	311839.161	3611.6895	60.0954
7/8	213.2361	4607.015	312701.184	3618 3500	60.1508
15/16	213.4324	4615.503	313565.796	3625.0168	60.2062
68 *in.*	213.6288	4624	314432	3631.6896	60.2616
1/16	213.8251	4632.503	315299.796	3638.3686	60.3169
1/8	214.0215	4641.015	316169.187	3645.0536	60 3723
3/16	214.2178	4649.535	317040.174	3651.7439	60.4277
1/4	214.4142	4658.062	317912.766	3658.4402	60.4831
5/16	214.6105	4666.597	318786.948	3665.1448	60.5385
3/8	214.8069	4675.140	319662.738	3671.8554	60.5939
7/16	215.0032	4683.691	320780.130	3678.5762	60.6493
1/2	215.1996	4692.25	321419.125	3685.2931	60.7047
9/16	215.3959	4700.816	322459.724	3692.0212	60.7601
5/8	215.5923	4709.390	323181.930	3698.7554	60.8155
11/16	215.7886	4717.972	324065.743	3703 9957	60.8708
3/4	215.9850	4726.562	324951.172	3712.2421	60.9262
13/16	216.1813	4735.160	325837.204	3718.9948	60.9816
7/8	216.3777	4743.765	326726.977	3725.7535	61.0371
15/16	216.5748	4752.378	327617.120	3732.5184	61.0924

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
69 *in.*	216.7704	4761	328509	3739.2894	61.1478
1/16	216.9667	4769.628	329402.495	3745.8166	61.2032
1/8	217.1631	4778.265	330297.609	3752.8498	61.2586
3/16	217.3594	4786.910	331194.243	3759.6382	61.3139
1/4	217.5558	4795.562	332092.703	3766.4327	61.3693
5/16	217.7521	4804.222	332715.428	3773.2355	61.4247
3/8	217.9485	4812 890	333894.285	3780.0443	61.4801
7/16	218.1448	4821.566	334797.517	3786.8628	61.5355
1/2	218 3412	4830.25	335702.375	3793.6783	61.5909
9/16	218.5375	4838.941	336508.861	3800.5191	61.6463
5/8	218.7339	4847.640	337516.977	3807.3369	61.7017
11/16	218.9302	4856.347	338426.718	3814.2781	61.7571
3/4	219.1266	4865.062	339338.109	3821.0200	61.8125
13/16	219.3229	4873.785	340241.122	3827.8708	61.8678
7/8	219.5193	4882.515	341165.778	3834.7277	61.9233
15/16	219.7156	4891.253	341982,069	3841.5908	61.9786
70 *in.*	219.9120	4900	343000	3848.4600	62.0341
1/16	220.1083	4908.753	343919.570	3855 8353	62.0893
1/8	220.3047	4917.515	344840.781	3862.2167	62.1448
3/16	220.5010	4926.285	345759.635	3869 1033	62.2001
1/4	220.6974	4935 062	346688.141	3875 9960	62 2555
5/16	220.8937	4943.847	347514.284	3882 8969	62.3109
3/8	221.0901	4952.640	348542.082	3889 8039	62.3663
7/16	221.2864	4961.441	349471 528	3896.7211	62.4217
1/2	221.4828	4970.25	350402 625	3903 6343	62 4771
9/16	221.6791	4979.066	351335 372	3910.5588	62 5325
5/8	221.8755	4987.890	352259.774	3917.4893	62.5879
11/16	222.0718	4996 722	353205.828	3924.4260	62 6432
3/4	222.2682	5005.562	354143.547	3931.3687	62 6986
13/16	222.4645	5014.410	355182 915	3938.3177	62.7541
7/8	222.6609	5023 265	356023,949	3945.2728	62.8094
15/16	222.8572	5032.128	356966.643	3952.2341	62.8648
71 *in.*	223.0536	5041	357911	3959.2014	62.9202
1/16	223.2499	5049.878	358857.019	3966 1749	62 9756
1/8	223.4463	5058.765	359804.703	3973.1545	63.0301
3/16	223.6426	5067 660	360754.053	3980.1393	63 0863
1/4	223.8390	5076 562	361705.078	3987.1301	63.1417
5/16	224.0353	5085 472	362657.764	3994.1292	63.1971
3/8	224.2317	5094.390	363612.129	4001.1344	63.2525
7/16	224.4280	5103.316	364568.165	4008.1447	63.3079
1/2	224.6244	5112.25	365525.875	4015.1611	63.3633
9/16	224.8207	5121.191	366485.259	4022.1837	63.4187
5/8	225.0171	5130.140	367446.320	4029.2124	63.4741
11/16	225.2134	5139.097	368409.059	4036.2473	63.5295
3/4	225.4098	5148.062	369373.484	4043.2882	63.5849
13/16	225.6061	5157.035	370339.583	4050.3354	63.6402
7/8	225.8025	5166.015	371307.371	4057.3886	63.6956
15/16	225.9988	5175.003	372276.843	4064.4481	63.7511

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
72 in.	226.1952	5184	373248	4071.5136	63.8064
1/16	226 3915	5193 003	374220 843	4078 5853	63 8617
1/8	226 5879	5202.015	375195.375	4085.6631	63.9171
3/16	226 7842	5211.035	376161.596	4092.7460	63.9725
1/4	226 9806	5220.062	377149.515	4099 8350	64.0279
5/16	227.1769	5229.097	378129.140	4106 9323	64.0833
3/8	227.3733	5238.140	379110.425	4114 0356	64.1367
7/16	227.5696	5247.191	380093 427	4121.1442	64.1941
1/2	227 7660	5256 25	381078.125	4128.2587	64.2495
9/16	227 9623	5265.316	382063 521	4135.3795	64 3049
5/8	228 1587	5274.390	383052 617	4142.5064	64 3603
11/16	228.3550	5283.472	384192.414	4149.6394	64.4157
3/4	228 5514	5292 562	385033 921	4156.7785	64.4711
13/16	228 7477	5301.650	386026.397	4163 9239	64.5264
7/8	228 9441	5310 765	387022 043	4171.0753	64 5818
15/16	229.1404	5319.878	388747.938	4178.2329	64.6372
73 in.	229 3368	5329	389017	4185 3966	64.6926
1/16	229.5331	5338 128	390017 042	4192 5665	64.7470
1/8	229.7295	5347.265	391018 797	4199.7424	64 8034
3/16	229.9258	5356.410	392013 264	4206.9250	64.8587
1/4	230 1222	5365 562	393027 453	4214.1107	94 9141
5/16	230 3185	5374 722	394034 350	4221 3027	64.9695
3/8	230.5149	5383.890	395042 972	4228.5077	65.0249
7/16	230.7112	5393.066	396053.313	4235 7109	65.0803
1/2	230.9076	5402.25	397065 375	4242 9271	65.1357
9/16	231.1039	5411.441	398079 157	4250 1461	65.1911
5/8	231.3003	5420.640	399094 664	4257 3711	65 2465
11/16	231.4966	5429.847	400111 865	4264 6023	65 3018
3/4	231.6930	5439.062	401130 859	4271 8396	65.3572
13/16	231.8893	5448.275	402150 805	4279 0831	65.4126
7/8	232 0857	5457.515	403173 964	4286 3327	65.4680
15/16	232.2820	5466.753	404198.116	4293 5885	65.5234
74 in.	232.4784	5476	405224	4300.8504	65.5788
1/16	232.6747	5485.253	406251.616	4308.1185	65.6341
1/8	232 8711	5494 515	407280 968	4315.3926	65 6895
3/16	233.0674	5503.785	408312.057	4322.1719	65.7449
1/4	233.2638	5513.062	409344.890	4329.9572	65.8003
5/16	233.4601	5522.347	410379.456	4337.2508	65.8557
3/8	233.6565	5531.640	411415 769	4344.5505	65 9111
7/16	233.8528	5540.941	412453 775	4351.8551	65 9665
1/2	234.0492	5550 25	413493 625	4359.1663	66 0219
9/16	234.2455	5559 566	414535.169	4366 4835	66.0773
5/8	234.4419	5568.890	415578.461	4373 8067	66.1327
11/16	234.6382	5578.222	416613 500	4381.1361	66.1880
3/4	234.8346	5587.562	417670 296	4388.4715	66.2434
13/16	235 0309	5596.900	418719.087	4396.3152	66.2988
7/8	235.2273	5606.265	419769.136	4403.1610	66.3542
15/16	235.4236	5615.628	420821.190	4410.5150	66.4096

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
75 in.	235.6200	5625	421875	4417.8750	66.4650
1/16	235.8163	5634 378	422930.566	4425.2412	66.5204
1/8	236 0127	5643 765	423987.890	4432.6135	66.5758
3/16	236.2090	5653 160	424046.975	4439.9910	66.6311
1/4	236.4054	5662 562	426107 828	4447.3745	66 6865
5/16	236.6017	5671 972	427170 436	4454 7663	66 7419
3/8	236.7981	5681.390	428234 816	4462.1642	66.7973
7/16	236 9944	5690.816	429300 952	4469.5672	66.8527
1/2	237.1908	5700.25	430368.875	4476.9763	66.9081
9/16	237.3871	5709.691	431438 541	4484.3916	66.9635
5/8	237 5835	5719.140	432510.007	4491.8130	67.0189
11/16	237.7798	5728 597	433583.230	4499.2406	67.0743
3/4	237.9762	5738.062	434658 234	4506.6742	67.1297
13/16	238.1725	5747.525	435734.246	4514.1141	67.1850
7/8	238 3689	5757.015	436813 558	4521.5600	67.2404
15/16	238.5652	5766 503	436893.889	4528.9622	67.2958
76 in.	238 7616	5776	438976	4536.4704	67.3512
1/16	238.9579	5785.503	440059 990	4543.9333	67.4066
1/8	239.1543	5795.015	441145.564	4551.4023	67.4610
3/16	239 3506	5804 535	442233 017	4558.8794	67.5173
1/4	239.5470	5814.062	443322.265	4566.3626	67.5727
5/16	239 7433	5823 597	444413.291	4573.8526	67 6281
3/8	239.9397	5833.140	445506.113	4581.3486	67.6835
7/16	240.1360	5842.691	446600.724	4588.8493	67.7389
1/2	240.3324	5852 25	447697.125	4596.3571	67 7943
9/16	240.5287	5861.816	448795.318	4603.8706	67.8497
5/8	240.7251	5871.390	449895.304	4611.3902	67.9051
11/16	240.9214	5880.972	450997.086	4618.9159	67.9605
3/4	241.1178	5890 562	452100.671	4626.4477	68.0159
13/16	241.3141	5900.150	453205.279	4633.9858	68 0712
7/8	241.5105	5909.765	454313.230	4641.5299	68.1266
15/16	241.7068	5919.378	455422.214	4649.0802	68.1821
77 in.	241 9032	5929	456533	4656.6366	68.2374
1/16	242 0995	5938.628	457645.589	4664.1992	68 2928
1/8	242 2959	5948.265	458759.984	4671.7678	68.3482
3/16	242.4922	5957.910	459820.610	4679.3416	68.4035
1/4	242.6886	5967.562	460994.203	4686.9215	68.4589
5/16	242 8849	5977.222	462114.022	4694.5097	68 5143
3/8	243 0813	5986.890	463235.660	4702.1039	68.5697
7/16	243.2776	5996 566	464359.110	4709.7033	68.6251
1/2	243 4740	6006.25	465484.375	4717.3087	68 6805
9/16	243.6703	6015 941	466611.474	4724.9204	68.7359
5/8	243.8667	6025.640	467740.351	4732.5381	68 7913
11/16	244.0630	6035 347	468871.166	4740.1620	68.8467
3/4	244.2594	6045.062	470003.609	4747.7920	68 9021
13/16	244.4557	6054.775	471027.187	4755.8782	68 9574
7/8	244.6521	6064.515	472274.152	4763.0705	69.0128
15/16	244.8484	6074.253	473413.963	4771.1690	69.0682

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
78 *in.*	245.0448	6084	474552	4778.3736	69.1236
1/16	245 2411	6093.753	475693 663	4786 0344	69.1790
1/8	245.4375	6103.515	476837.156	4793.7012	69.2343
3/16	245.6338	6113.285	477982.478	4801.3732	69.2897
1/4	245 8302	6123.062	479129.670	4809.0512	69.3451
5/16	246 0265	6132.847	480277.627	4817.1375	69.4006
3/8	246 2229	6142.640	481429.457	4824.4299	69.4559
7/16	246.4192	6152.441	482582.114	4832.1275	69.5113
1/2	246.6156	6162.25	483736.625	4839.8311	69.5667
9/16	246.8119	6172.066	484752.966	4847.5409	69.6221
5/8	247.0083	6181.890	486051.148	4855.2568	69.6775
11/16	247.2046	6191.722	487211.272	4362.9789	69.7329
3/4	247.4010	6201.562	488373.047	4870 7071	69.7883
13/16	247.5973	6211.400	489736.071	4878.4415	69.8437
7/8	247.7937	6221.265	490702.324	4886.1820	69.6991
15/16	247.9900	6231.128	491769.737	4893.9287	69.9544
79 *in.*	248 1864	6241	493039	4901.6814	70.0096
1/16	248.3827	6250 878	494210.113	4909.4403	70.0652
1/8	248.5791	6260 765	495383 078	4917.2053	70.1206
3/16	248.7754	6270 660	496557.896	4924.9755	70.1760
1/4	248 9718	6280 562	497734.578	4932.7517	70.2314
5/16	249.1681	6290.472	498913.108	4940 5362	70.2867
3/8	249 3645	6300 390	500093.504	4948 3268	70.3421
7/16	249 5608	6310.316	501275.757	4956.1225	70.3975
1/2	249.7572	6320.25	502459 875	4963 9243	70.4529
9/16	249 9535	6330.191	503645.853	4971.7319	70.5083
5/8	250 1499	6340.140	504833 695	4979 5456	70.5637
11/16	250.3462	6350 097	506023 401	4987.3663	70.6191
3/4	250 5426	6360 062	507214 992	4995.1930	70.6745
13/16	250 7389	6370 025	508407 621	5003 0316	70.7298
7/8	250 9353	6380 015	509603 746	5010 8642	70 7853
15/16	251.1316	6390.003	510800.936	5018.7091	70.8406
80 *in.*	251 3280	6400	512000	5026.5600	70.8960
1/16	251.5243	6410.003	513200.937	5034.4171	70.9513
1/8	251.7207	6420.015	514403.750	5042 2803	71.0068
3/16	251.9170	6430.035	515608.439	5050.1486	71.0622
1/4	252 1134	6440.062	516815.016	5058 0230	71.1176
5/16	252 3097	6450.097	518033.463	5065 9027	71.1729
3/8	252 5061	6460.140	519233.801	5073 7944	71.2283
7/16	252 7024	6470.191	520446 020	5081 6883	71.2837
1/2	252 8988	6480 25	521660.125	5089.5883	71.3391
9/16	253 0951	6490.316	522876.114	5097.4941	71.3945
5/8	253 2915	6500 390	524093 992	5105.4060	71.4499
11/16	253 4878	6510 472	525313.758	5113.8248	71.5053
3/4	253.6842	6520 562	526535.422	5121.2497	71.5607
13/16	253 8805	6530.660	527758 969	5129.1855	71 6161
7/8	254 0769	6540.765	528984.418	5137.1173	71.6715
15/16	254.2732	6550.878	530210.761	5145.0603	71.7268

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
81 *in.*	254.4696	6561	531441	5153.0094	71.7822
1/16	254.6659	6571.128	532672.136	5160.9647	71.8376
1/8	254.8623	6581.265	533903.172	5168.9260	71.8930
3/16	255.0586	6591.410	535140.107	5176.8925	71.9484
1/4	255.2550	6601.562	536376 953	5184.8651	72.0037
5/16	255.4513	6611.722	537615 694	5192.8460	72.0591
3/8	255.6477	6621.890	538856 347	5200.8329	72.1145
7/16	255 8440	6632 066	540098.907	5208.8250	72.1699
1/2	256 0404	6642.25	541343.375	5216.8231	72.2253
9/16	256.2367	6652.441	542589.751	5224.8271	72 2807
5/8	256.4331	6662.640	543838.039	5232.8371	72.3361
11/16	256.6294	6672 847	545088.238	5240.8568	72.3915
3/4	256.8258	6683.062	546340.359	5248 8772	72.4469
13/16	257.0221	6693 285	547594.387	5256.9061	72.5023
7/8	257.2105	6703.515	548850 339	5264.9411	72.5577
15/16	257.4148	6713.753	550108.211	5272.9828	72.6130
82 *in.*	257.6112	6724	551368	5281.0296	72.6684
1/16	257.8075	6734.253	552629.710	5289.0781	72.7237
1/8	258 0039	6744.515	553863 343	5297.1426	72.7792
3/16	258.2002	6754 785	555158.900	5305.2073	72.8346
1/4	258 3966	6765 062	556426.390	5313.2780	72.8801
5/16	258.5929	6775.347	557695.799	5321.3570	72.9453
3/8	258 7893	6785.640	558967.144	5329.4421	73.0007
7/16	258.9856	6795 941	559140.118	5337.5324	73.0561
1/2	259.1820	6806.25	561515.625	5345.6287	73.1115
9/16	259.3783	6816.566	563292.769	5353 7809	73.1669
5/8	259 5747	6826 890	564071.836	5361.8391	73 2224
11/16	259.7710	6837.222	565352 844	5369 9543	73.2777
3/4	259.9674	6847.562	566635.797	5378.0755	73.3330
13/16	260.1637	6857 910	567900.480	5386.2026	73.3885
7/8	260 3601	6868 265	569207.511	5394.3358	73.4438
15/16	260 5564	6878.628	570496.284	5402.4552	73.4993
83 *in.*	260.7528	6889	571787	5410.6206	73.5546
1/16	260 9491	6899.378	573079.659	5418.7722	73.6101
1/8	261.1455	6909.765	574374.265	5426.9299	73.6653
3/16	261.3418	6920.160	575670.818	5435.0928	73.7208
1/4	261.5382	6930.562	576969.328	5443.2617	73.7761
5/16	261.7345	6940 972	578269 769	5451.4389	73.8315
3/8	261.9309	6951.390	579572.191	5459.6222	73 8869
7/16	262 1272	6961.816	580876.556	5467.8106	73.9423
1/2	262.3236	6972 25	582182.875	5476.0051	73 9977
9/16	262.5199	6982 691	583491.150	5484 2054	74.0531
5/8	262 7163	6993.140	584801.382	5492.4118	74.1085
11/16	262.9126	7003.597	586113.574	5500.6252	74.1639
3/4	263.1090	7014.062	587427.734	5508.8446	74.2193
13/16	263.3053	7024.535	589067 048	5517.0699	74.2747
7/8	263.5017	7035.015	590061.933	5525.3012	74.3301
15/16	263.6980	7045.503	591381.983	5533.5388	74.3854

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
84 in.	263.8944	7056	592704	5541.7624	74.4408
1/16	264.0907	7065.503	593943.922	5550.0322	74.4962
1/8	264.2871	7077.015	595353.937	5558 2881	74.5516
3/16	264.4834	7087.535	596794.862	5566.5491	74.6070
1/4	264.6798	7098.062	598011.765	5574.8162	74.6624
5/16	264.8761	7108.597	599343.635	5583.0916	74.7177
3/8	265.0725	7119.140	600677.488	5591.3730	74.7731
7/16	265.2688	7129.691	602012.317	5599.6596	74.8385
1/2	265.4652	7140.25	603351.125	5607.9523	74.8839
9/16	265.6615	7150.816	604690.912	5616.2508	74.9393
5/8	265.8579	7161.390	606032.679	5624.5554	74.9947
11/16	266.0542	7171.972	607376.429	5632.8662	75.0601
3/4	266.2506	7182.562	608722.172	5641.1845	75.1055
13/16	266.4469	7193.160	609969.891	5649.5071	75.1608
7/8	266.6433	7203.765	611419.605	5657.8357	75.2162
15/16	266.8396	7214.378	612771.408	5666.1723	75.2716
85 in.	267.0360	7225	614125	5674 5150	75.3269
1/16	267.2323	7235.628	615480.693	5682.8630	75.3824
1/8	267.4287	7246.265	616838.359	5691.2170	75.4378
3/16	267.6250	7256.910	618198.029	5699 5762	75.4931
1/4	267.8214	7267.562	619559.703	5707.9415	75.5486
5/16	268.0177	7278.222	620923.365	5716.3151	75.6039
3/8	268.2141	7288.890	622289.035	5724.6947	75.6593
7/16	268 4104	7299.566	623656.713	5733.0795	75.7147
1/2	268 6068	7310.25	625026.375	5741.4703	75.7701
9/16	268 8031	7320.941	626398.048	5749.8670	75.8255
5/8	268.9997	7331.640	627771.726	5758.2697	75.8809
11/16	269.1958	7342.347	629147.409	5766.6794	75 9363
3/4	269.3922	7353.062	630525.109	5775.0952	75.9917
13/16	269.5885	7363.785	631904.808	5783.5168	76.0471
7/8	269.7849	7374.515	633286.527	5791.9445	76.1025
15/16	269.9812	7385.253	634670.257	5800.3784	76.1578
86 in.	270.1776	7396	636056	5808.8184	76.2132
1/16	270.3739	7406.753	637443.757	5817.2651	76.2686
1/8	270.5703	7417.515	638833.531	5825.7168	76.3240
3/16	270.7666	7428.285	640325.320	5834.1742	76.3794
1/4	270 9630	7439.062	641619.140	5842.6376	76.4347
5/16	271.1593	7449.847	643014.971	5851.1093	76.4901
3/8	271.3557	7460.640	644412.832	5859.5871	76.5455
7/16	271.5520	7471.441	645812.722	5868.0701	76.6009
1/2	271.7484	7482.25	647214.625	5876.5591	76.6563
9/16	271.9447	7493.066	648078.560	5885.0540	76.7117
5/8	272.1411	7503 890	650024.523	5893.5549	76.7671
11/16	272.3374	7514.722	651432.515	5902.0620	76.8225
3/4	272 5338	7525.562	652842.547	5910.5767	76.8779
13/16	272 7301	7536.410	654254.601	5919.0965	76.9333
7/8	272.9265	7547.265	655668.699	5927.6224	76.9887
15/16	273.1228	7558.128	656984.831	5936.1545	77.0441

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
87 in.	273.3192	7569	658503	5944.6926	77.0994
1/16	273.5155	7579.878	659913.206	5953.2369	77.1548
1/8	273.7119	7590.765	661345.453	5961.7873	77.2102
3/16	273.9082	7601.660	662769.740	5970.3429	77.2655
1/4	274.1046	7612.562	664196.078	5978.9045	77.3210
5/16	274.3009	7623.472	665618.451	5987.4749	77.3763
3/8	274.4973	7634.390	667054.878	5996.0504	77.4317
7/16	274.6936	7645.316	668487.353	6004.6315	77.4871
1/2	274.8900	7656.25	669921.875	6013.2187	77.5425
9/16	275.0863	7667.191	671368.487	6021.8117	77.5979
5/8	275.2827	7678.140	672797.070	6030.4108	77.6533
11/16	275.4790	7689.097	674237.746	6039.0169	77.7086
3/4	275.6754	7700.062	675680.484	6047.6290	77.7640
13/16	275.8717	7711.035	677125.269	6056.2470	77.8194
7/8	276.0681	7722.015	678572.121	6064.8710	77.8748
15/16	276.2644	7733.003	680021.030	6073.5013	77.9302
88 in.	276.4608	7744	681472	6082.1376	77.9856
1/16	276.6671	7755.003	682925.031	6090.7801	78.0409
1/8	276.8535	7766.015	684380.125	6099.4287	78.0964
3/16	277.0498	7777.035	685837.283	6108.0824	78.1518
1/4	277.2462	7788.062	687296.516	6116.7422	78.2071
5/16	277.4425	7799.097	688757.807	6125.4103	78.2625
3/8	277.6389	7810.140	690221.175	6134.0844	78.3179
7/16	277.8352	7821.191	691686.614	6144.2637	78.3733
1/2	278.0316	7832.25	693154.125	6151.4491	78.4287
9/16	278.2279	7843.316	694623.708	6160.1403	78.4841
5/8	278.4243	7854.390	696095.367	6169.8376	78.5395
11/16	278.6206	7865.472	697569.001	6177.5418	78.5949
3/4	278.8170	7876.562	699044.922	6186.2521	78 6503
13/16	279.0133	7887.660	700522.883	6194.9683	78.7057
7/8	279.2097	7898.765	702002 793	6203.6905	78.7610
15/16	279.4060	7909.878	703484.744	6212.4189	78.8164
89 in.	279.6024	7921	704969	6221.1534	78.8718
1/16	279.7987	7932.128	706455.230	6229.8941	78.9272
1/8	279.9951	7943.265	707943.547	6238.6408	78.9826
3/16	280.1914	7954.410	709434.951	6247.3927	79.0379
1/4	280.3878	7965.562	710926.453	6256.1507	79.0934
5/16	280.5841	7976.722	712421.027	6264.9170	79.1487
3/8	280.7805	7987.890	713907.722	6273.6893	79.2041
7/16	280.9768	7999.066	715405 501	6282.4668	79.2595
1/2	281.1732	8010.25	716917.375	6291.2503	79.3149
9/16	281.3695	8021.441	718420.345	6300.0397	79.3703
5/8	281.5659	8032.640	719925.414	6308.8351	79.4258
11/16	281.7622	8043.847	721432.542	6317.6375	79.4811
3/4	281.9586	8055.062	723051.859	6326.4460	79.5364
13/16	282.1549	8066.285	724258 230	6335.2603	79.5919
7/8	282.3513	8077.515	725966.714	6344.0807	79.6473
15/16	282.5476	8088.753	727482.304	6352.9073	79.7026

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
90 *in.*	282.7440	8100	729000	6361.7400	79.7580
1/16	282.9403	8111.253	730519.804	6370.5789	79.8134
1/8	283.1367	8122.515	732041.718	6379.4238	79.8688
3/16	283.3330	8133.785	733565.644	6388.7739	79.9242
1/4	283.5294	8145.062	735091.890	6397.1300	79.9796
5/16	283.7257	8156.347	736619.742	6405 9944	80.0349
3/8	283 9221	8167.640	738150.519	6414.8649	80.0903
7/16	284.1184	8178.941	739683.013	6423.7906	80.1457
1/2	284 3148	8190.25	741217.625	6432.6223	80.2011
9/16	284.5111	8201.566	742754.357	6441.5101	80.2565
5/8	284 7075	8212.890	744293.210	6450.4039	80.3119
11/16	284 9038	8224.222	745824.187	6459.3043	80.3673
3/4	285.1002	8235.562	747377.297	6468.2107	80.4227
13/16	285.2965	8246 910	748522.523	6477.1232	80.4781
7/8	285 4929	8258 265	750469.886	6486 0418	80.5335
15/16	285.6892	8269.628	752019.378	6494.9566	80.5888
91 *in.*	285.8856	8281	753571	6503.8974	80.6442
1/16	286 0819	8292.378	755124.753	6512.8344	80.6996
1/8	286.2783	8303.765	756680 640	6521.7775	80.7550
3/16	286.4746	8315.160	758238 661	6530.7258	80.8104
1/4	286.6710	8326 562	759798 828	6539.6801	80.8658
5/16	286 8673	8337 972	761361.123	6548.6427	80.9211
3/8	287.0637	8349.390	762925 566	6557.6114	80 9765
7/16	287.2600	8360.816	764492.149	6566.5857	81.0319
1/2	287.4564	8372.25	766060 875	6573.5651	81.0873
9/16	287.6527	8383 691	767631.744	6584.5511	81.1427
5/8	287.8491	8395.140	769204.757	6593.5431	81.1981
11/16	288 0454	8406 597	770779.917	6602.5443	81.2535
3/4	288 2418	8418.062	772357.234	6611 5462	81.3089
13/16	288 4381	8429.535	773935.773	6620.5569	81.3643
7/8	288 6345	8441.015	775518 308	6629.5736	81.4197
15/16	288.8388	8452.503	777102.077	6638.5967	81.4750
92 *in.*	289.0272	8464	778688	6647.6258	81.5304
1/16	289.2235	8475.503	780276.077	6656.6609	81.5858
1/8	289 4199	8487.015	781866.312	6665.7021	81.6412
3/16	289 6162	8498.535	783448 704	6674.7485	81.6966
1/4	289 8125	8510.062	785053.265	6683.8010	81.7519
5/16	290.0089	8521.597	786649 978	6692.8618	81.8073
3/8	290.2053	8533.140	788248.863	6701.9286	81.8627
7/16	290.4016	8544.691	789849.911	6711.5001	81.9181
1/2	290.5980	8556.25	791453 125	6720.0787	81.9735
9/16	290 7943	8567.816	793057.505	6729.6628	82.0289
5/8	290 9907	8579.390	794666.054	6738.2530	82.0843
11/16	291.1870	8590.972	796275.773	6747.3497	82.1397
3/4	291.3834	8602.562	797887.672	6756.4525	82.1950
13/16	291.5797	8614.160	799501.734	6765.5614	82.2505
7/8	291.7761	8625.765	801117.980	6774.6763	82.3059
15/16	291.9724	8637.378	802736.411	6783.7975	82.3612

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
93 *in.*	292.1688	8649	804357	6792.9248	82.4166
1/16	292.3651	8660.628	805979.777	6802.0581	82.4720
1/8	292.5615	8672.265	807604.734	6811.1974	82.5274
3/16	292.7578	8683.910	809231.872	6820.3420	82.5828
1/4	292.9542	8695.562	810861.203	6829.4927	82.6382
5/16	293.1505	8707.222	812492.708	6838.6517	82.6935
3/8	293.3469	8718.890	814126.410	6847.8167	82.7489
7/16	293.5432	8730.566	815762.298	6856.9869	82.8043
1/2	293.7396	8742.25	817400.375	6866.1631	82.8597
9/16	293.9359	8753.941	819040.642	6875.3454	82.9151
5/8	294.1323	8765.640	820683.101	6884.5338	82.9705
11/16	294.3286	8777.347	822328.353	6893.7337	83.0259
3/4	294 5350	8789.062	823974.610	6902.9296	83.0813
13/16	294.7213	8800.785	825623.652	6912.1366	83.1367
7/8	294.9177	8812.515	827274.902	6921.3497	83.1921
15/16	295.1140	8824.253	828928.351	6930.5691	83.2475
94 *in.*	295.3104	8836	830584	6939.7946	83.3028
1/16	295.5067	8847.753	832041.851	6949.5261	83.3582
1/8	295.7031	8859.515	833901.906	6958.2636	83.4136
3/16	295.8994	8871.285	835564.165	6968.0064	83.4690
1/4	296.0958	8883.062	837228 640	6976.7552	83.5244
5/16	296.2921	8894.847	838885.214	6986.0123	83.5797
3/8	296.4885	8906.640	840564.207	6995.2755	83.6351
7/16	296.6848	8918.441	842235.209	7004.5439	83.6905
1/2	296.8812	8930.25	843908.625	7013.8183	83.7459
9/16	297.0775	8942.066	845621.988	7023 0988	83.8013
5/8	297.2739	8953.890	847261.898	7032.3853	83.8567
11/16	297.4702	8965.722	848831.858	7041.6784	83.9121
3/4	297.6666	8977.562	850624.047	7050 9775	83.9675
13/16	297.8629	8989.410	852206.445	7060.2827	84.0229
7/8	298.0593	9001.265	853995.074	7069 5940	84.0783
15/16	298.2556	9013.128	856491.925	7075.9116	84.1336
95 *in.*	298.4520	9025	857375	7088.2352	84.1890
1/16	298.6483	9036.878	859068.300	7097.5738	84.2444
1/8	298.8447	9048.765	860763.828	7106 9005	84.2998
3/16	299.0400	9060.660	862461.583	7116 7415	84.3552
1/4	299.2374	9072.562	864161.578	7125.5885	84.4106
5/16	299.4337	9084.472	865863 794	7134.9443	84.4660
3/8	299.6301	9096.390	867568.253	7144.3052	84.5213
7/16	299 8264	9108.316	869274.947	7153.6717	84.5767
1/2	300.0228	9120.25	870983.875	7163.0443	84.6321
9/16	300.2191	9132.191	872695.140	7172.4230	84.6875
5/8	300.4155	9144.140	874408.445	7181.8077	84.7429
11/16	300.6118	9156.097	876124.009	7191.1989	84.7983
3/4	300.8082	9168.062	877841 984	7200 5962	84.8537
13/16	301.0045	9180.035	879566 903	7209.9096	84.9091
7/8	301.2009	9192.015	881284.495	7219.4090	84.9645
15/16	301.3972	9204.003	883009.124	7228.8248	85.0199

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of — square
96 *in.*	301.5936	9216	884736	7238.2466	85.0752
1/16	301.7899	9228.003	886465.124	7247.6741	85.1306
1/8	301.9863	9248.015	888965.499	7257.1083	85.1860
3/16	302.1826	9252.035	889930.126	7266.5474	85.2414
1/4	302.3790	9264.062	891666.015	7275.9926	85 2967
5/16	302.5753	9276.097	893401.160	7285.4461	85.3521
3/8	302.7717	9288.140	894944 550	7294.9056	85.4075
7/16	302.9680	9300.191	896887.208	7304.3703	85.4629
1/2	303.1644	9312.25	898632.125	7313 8411	85.5183
9/16	303.3607	9324.316	900379.302	7323.3179	85.5737
5/8	303.5571	9336.390	902128.742	7332.8008	85.6291
11/16	303.7534	9348.472	903786.444	7342.2902	85.6845
3/4	303.9498	9360.562	905634.422	7351.7857	85.7399
13/16	304.1461	9372.660	907397.655	7361.2873	85.7952
7/8	304.3425	9384.765	909149.167	7370.7949	85.8506
15/16	304.5388	9396.878	910909.948	7380.3088	85.9060
97 *in.*	304.7352	9409	912673	7389.8288	85.9614
1/16	304.9315	9421.128	914438.324	7399.3548	86.0167
1/8	305.1279	9433.265	916205.921	7408.8868	86.0722
3/16	305.3242	9445.410	916974.794	7418.6241	86.1276
1/4	305.5206	9457.562	919747.953	7427.9675	86.1830
5/16	305 7169	9469.722	921522.380	7437.5192	86.2383
3/8	305.9133	9481.890	923299.097	7447.0769	86.2937
7/16	306.1096	9494.066	924078.095	7456.6398	86.3491
1/2	306.3060	9506.25	926859.375	7466.2987	86.4045
9/16	306.5023	9518.441	928642.939	7475.7837	86.4599
5/8	306.6987	9530.640	930428.788	7485.3648	86.5153
11/16	306.8950	9542.847	932215.924	7494.9524	86.6570
3/4	307.0914	9555.062	934007.359	7504.5460	86.6626
13/16	307.2877	9567.285	935800.073	7514.1457	86.6814
7/8	307.4841	9579.515	937595.089	7523.7515	86.7368
15/16	307.6804	9591.753	939392.397	7533.3636	86.7922
98 *in.*	307.8768	9604	941192	7542.9818	86.8476
1/16	308.0731	9616.253	942993.898	7552.6060	86.9030
1/8	308 2695	9628.515	944789.093	7562.2362	86.9584
3/16	308.4658	9640.785	946604.587	7575.8717	87.0138
1/4	308.6622	9653.062	948413.390	7581.5132	87.0692
5/16	308.8585	9665.347	950224.485	7591.1630	87.1245
3/8	309.0549	9677.640	952037.894	7600.8189	87.1799
7/16	309.2512	9689.941	953852.606	7610.4800	87.2353
1/2	309.4476	9702.25	955671.625	7620.1471	87.2907
9/16	309.6439	9714.566	957591.730	7629.8203	87.3461
5/8	309.8403	9726.890	959314.585	7639.4995	87.4015
11/16	310.0366	9739.222	961139.530	7649.1853	87.4569
3/4	310.2330	9751.562	962966.797	7658.8771	87.5123
13/16	310.4293	9763.910	964956.366	7668.5750	87.5677
7/8	310.6257	9776.265	966628.261	7678.2790	87.6231
15/16	310.8220	9788.628	968362.471	7687.9893	87.6785

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
99 *in.*	311.0184	9801	970299	7697.7056	87.7338
1/16	311.2147	9813.378	972137.847	7707.4279	87.7892
1/8	311.4111	9825.765	973979.015	7717.1563	87.8446
3/16	311.6074	9838.160	975821.504	7726.8900	87.9001
1/4	311.8038	9850.562	977668.328	7736.6297	87.9554
5/16	312.0001	9862.972	979516.476	7746.3777	88.0107
3/8	312.1965	9875.390	981366.941	7756.1318	88.0661
7/16	312.3928	9887.816	983218.743	7765.8910	88.1215
1/2	312.5892	9900.25	985074.875	7775.6563	88.1769
9/16	312.7855	9912.691	986932.357	7785.4277	88.2323
5/8	312.9819	9925.140	988792.132	7795.2051	88.2877
11/16	313.0782	9937.597	990654.210	7804.9890	88.3431
3/4	313.3746	9950.062	992518.734	7814.7790	88.3985
13/16	313.5709	9962.535	994385.534	7824.5751	88.4539
7/8	313.7673	9975.015	996254.683	7834.3772	88.5093
15/16	313.9636	9987.503	998122.170	7844.1856	88.5646
100 *in.*	314.1600	10000	1000000	7854.0000	88.6200
1/4	314.9454	10050.062	1007518.765	7893.3190	88.8415
1/2	315.7308	10100.25	1015075.125	7932.7360	89.0631
3/4	316.5162	10150.562	1022669.171	7972.2120	89.2847
101 *in.*	317.3016	10201	1030301	8011.8652	89.5062
1/4	318.0870	10251.562	1037970.703	8051.5772	89.7278
1/2	318.8724	10302.25	1045678.37	8091.3870	89.9493
3/4	319.6578	10353.062	1053424.109	8131.2953	90.1709
102 *in.*	320.4432	10404	1061208	8171.3016	90.3924
1/4	321.2286	10455.062	1069030.140	8211.4060	90.6140
1/2	322.0140	10506.25	1076890.625	8251.6084	90.8355
3/4	322.7994	10557.562	1084789.546	8291.8696	91.0571
103 *in.*	323.5848	10609	1092727	8332.3085	91.2786
1/4	324.3702	10660.562	1100703.078	8372.8056	91.5002
1/2	325.1556	10712.25	1108717.875	8413.4008	91.7217
3/4	325.9410	10764.059	1116771.173	8454.0944	91.9433
104 *in.*	326.7264	10816	1124864	8494.8864	92.1648
1/4	327.5118	10868.062	1132995.526	8535.7760	92.3864
1/2	328.2972	10920.25	1141166.125	8576.7640	92.6079
3/4	329.0826	11032.562	1155660.921	8617.8504	92.8295
105 *in.*	329.8680	11025	1157625	8659.0348	93.0510
1/4	330.6534	11077.562	1165913.453	8700.3176	93.2726
1/2	331.4388	11130.25	1174241.375	8741.6980	93.4941
3/4	332.2242	11183.062	1182608.859	8783.1772	93.7157
106 *in.*	333.0096	11236	1191016	8824.7544	93.9372
1/2	334.5804	11342.25	1207949.625	8908.2028	94.3803

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
107 *in.*	336.1512	11449	1225043	8992.0444	94.8234
½	337.7220	11556.25	1242296.875	9076.2784	95.2665
108 *in.*	339.2928	11664	1259712	9160.9056	95.7096
½	340.8636	11772.25	1277289.125	9245.9248	96.1527
109 *in.*	342.4344	11881	1295029	9331.3372	96.5958
½	344.0052	11990.25	1312932.376	9417.1420	97.0389
110 *in.*	345.5760	12100	1331000	9503.3400	97.4820

A TABLE

CONTAINING

THE CIRCUMFERENCES & AREAS OF CIRCLES,

From 1 to 50 Feet, advancing by an Inch;

ALSO,

THE SIDE OF A SQUARE OF EQUAL AREA,

AND THE

Content of each in Imperial Gallons and Cubic Yards, at 1 Foot in depth.

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
1 *ft.*	3 1⅝	.7854	0 10⅝	4.8946	.0291
1	3 4⅝	.9217	0 11⅛	5 7440	.0341
2	3 8	1.0690	1 0⅜	6.6620	.0395
3	3 11	1.2271	1 1¼	7 6472	.0454
4	4 2⅛	1.3962	1 2⅛	8.7011	.0517
5	4 5⅝	1.5761	1 3	9.8222	.0583
6	4 8½	1.7671	1 3⅞	11.0125	.0654
7	4 11⅝	1.9689	1 4⅝	12.2701	.0729
8	5 2¾	2.1816	1 5⅝	13.5957	.0808
9	5 5⅞	2.4052	1 6⅛	14 9892	.0890
10	5 9	2 6398	1 7⅛	16 4512	.0977
11	6 2¼	2.8852	1 8⅛	17 9025	.1068
2 *ft.*	6 3⅜	3.1416	1 9¼	19.5784	.1163
1	6 6½	3.4087	1 10⅛	21 2430	.1262
2	6 9⅝	3.6869	1 11	22 9767	.1365
3	7 0¾	3.9760	1 11⅞	24 7784	.1472
4	7 3⅞	4.2760	2 0¾	27 2480	.1583
5	7 7	4.5869	2 1⅝	28.5855	.1698
6	7 10¼	4.9087	2 2½	30.5910	.1818
7	8 1⅜	5.2413	2 3⅜	32.6637	.1941
8	8 4½	5.5850	2 4¼	34.8057	.2068
9	8 7⅝	5.9395	2 5¼	37.0149	.2199
10	8 10¾	6.3049	2 6⅛	39.2921	.2335
11	9 1⅞	6.6813	2 7	41.6378	.2474
3 *ft.*	9 5	7.0686	2 7⅞	44.0515	.2618
1	9 8¼	7.4666	2 8¾	46.5318	.2765
2	9 11⅜	7.8757	2 9⅝	49.0813	.2916
3	10 2½	8.2957	2 10¼	51.6988	.3072
4	10 5⅝	8.7265	2 11⅛	54.3835	.3232
5	10 8¾	9.1683	3 0¼	57.0994	.3395
6	10 11⅞	9.6211	3 1⅛	60.9587	.3565
7	11 3	10.0846	3 2	62.8472	.3733
8	11 6⅛	10.5591	3 3	65.8043	.3911
9	11 9⅜	11.0446	3 3⅞	68.8299	.4090
10	12 5⅛	11.5409	3 4⅝	71.9228	.4274
11	12 3⅝	12.0481	3 5⅝	75.0837	.4462
4 *ft.*	12 6¾	12.5664	3 6⅛	78.3128	.4654
1	12 9⅞	13.0952	3 7⅛	81.6092	.4851
2	13 1	13.6353	3 8¼	84.9751	.5050
3	13 4⅛	14.1862	3 9⅛	85.8583	.5254
4	13 7¼	14.7479	3 10	91.9089	.5462
5	13 10⅛	15.3206	3 10⅞	95 4779	.5674
6	14 1⅝	15.9043	3 11⅞	99 1155	.5893
7	14 4⅝	16.4986	4 0⅝	102 8192	.6112
8	14 7⅞	17.1041	4 1⅝	106.5927	.6334
9	14 11	17.7205	4 2½	110 4341	.6563
10	15 2⅜	18.3476	4 3⅜	114 3421	.6795
11	15 5¼	18.9858	4 4¼	118 3818	.7032

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
5 *ft.*	15 8½	19 6350	4 5⅛	122.3653	.7272
1	15 11⅝	20 2947	4 6	126.4765	.7516
2	16 2¾	20 9656	4 6⅞	130 6576	.7764
3	16 5¾	21 6475	4 7¾	134.9072	.8017
4	16 9	22 3400	4 8⅝	139.2228	.8275
5	17 0⅛	23 0437	4 9½	143.6083	.8534
6	17 3¼	23 7583	4 10⅜	148.0617	.8800
7	17 6⅜	24 4835	4 11⅛	152.5811	.9071
8	17 9⅝	25 2199	5 0¼	157.1704	.9340
9	18 0¾	25 9672	5 1⅛	161.8275	.9617
10	18 3⅞	26 7251	5 2	166.5508	.9897
11	18 7⅛	27 4943	5 2⅞	171.3444	1.0184
6 *ft.*	18 10⅛	28 2744	5 3¾	176.2060	1.0472
1	19 1¼	29 0649	5 4⅝	181.1324	1.0764
2	19 4⅜	29 8668	5 5½	185.1298	1.1042
3	19 7½	30.6796	5 6⅜	191.1952	1.1363
4	19 10⅝	31 5029	5 7⅜	196.3320	1.1667
5	20 1⅞	32.3376	5 8¼	201 5279	1.1976
6	20 4⅞	33.1831	5 9⅛	206.7970	1.2290
7	20 8⅛	34.0391	5 10	212.1376	1.2607
8	20 11½	34 9065	5 10⅞	217.5373	1.2928
9	21 2⅝	35.7847	5 11⅝	223.0102	1.3253
10	21 5½	36.6735	6 0⅝	228.4492	1.3582
11	21 8¾	37.5736	6 1½	234.1586	1.3926
7 *ft.*	21 11⅞	38.4846	6 2⅜	239.8360	1.4254
1	22 3	39.4060	6 3¼	245.5781	1.4602
2	22 6⅛	40.3388	6 4⅛	251.3914	1.4940
3	22 9¼	41.2825	6 5⅛	257.2725	1.5300
4	23 0⅜	42.2367	6 6	263.2191	1.5643
5	23 2⅝	43.2022	6 6⅞	269.2361	1.6001
6	23 6¾	44.1787	6 7⅝	275.3216	1.6361
7	23 11	45.1656	6 8⅝	281.4720	1.6728
8	24 1⅛	46.1638	6 9½	287.6928	1.7098
9	24 4⅛	47.1730	6 10⅜	293.9721	1.7471
10	24 7¼	48.1926	6 11¼	300.3362	1.7849
11	24 10⅜	49.2236	7 0	306.7614	1.8231
8 *ft.*	25 1½	50.2656	7 0⅞	313.2552	1.8617
1	25 4⅝	51.3178	7 1⅝	319.8125	1.9007
2	25 7⅞	52 3816	7 2⅞	326.4421	1.9394
3	25 11	53.4562	7 3⅝	333.1390	1.9800
4	26 2⅛	54.5412	7 4⅝	339.9007	2.0201
5	26 5¼	55.6377	7 5½	346 7341	2.0607
6	26 8⅜	56.7451	7 6⅜	353.6354	2.1017
7	26 11½	57.8628	7 7¼	360.6009	2.1430
8	27 2¾	58.9920	7 8⅛	367.6381	2.1850
9	27 5¾	60.1321	7 9⅛	374.3432	2.2698
10	27 9	61.2826	7 9⅞	381.9031	2.3128
11	28 0⅛	62.4445	7 10⅝	389.1541	2.4001

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
9 *ft.*	28 3¼	63.6174	7 11⅝	396.4636	2.3562
1	28 6⅝	64.8006	8 0½	403.8373	2.4000
2	28 9½	65.9951	8 1½	411.2814	2.4443
3	29 0⅜	67.2007	8 2⅜	418.7947	2.4889
4	29 3¼	68.4166	8 3¼	426.3722	2.5339
5	29 7	69.6440	8 4⅛	434.0214	2.5795
6	29 10⅛	70.8823	8 5	441.7384	2.6263
7	30 1¼	72.1309	8 5⅞	449.5197	2.6715
8	30 4⅜	73.3910	8 6¾	457.3727	2.7183
9	30 7½	74.6620	8 7⅝	465.2935	2.7653
10	30 11⅝	75.9433	8 8½	473.2786	2.8128
11	31 1¾	77.2362	8 9½	481.3359	2.8607
10 *ft.*	31 5	78.5400	8 10¼	489.4612	2.9089
1	31 8⅛	79.8540	8 11¼	497.6501	2.9575
2	31 11¼	81.1795	9 0⅛	505.9106	3.0066
3	32 2⅜	82.5160	9 1	514.2397	3.0561
4	32 5½	83.8627	9 1⅞	522 6323	3.1060
5	32 8⅝	85.2211	9 2¾	530.9978	3.1563
6	32 11¾	86.5903	9 3⅝	539.6307	3.2070
7	33 2⅞	87.9697	9 4½	548.2271	3.2211
8	33 6⅛	89.3608	9 5⅜	556.8965	3.3096
9	33 9¼	90.7627	9 6¼	565.2331	3.3615
10	34 0⅜	92.1749	9 7¼	574.4339	3.4138
11	34 3½	93.5986	9 8⅛	583.3064	3.4665
11 *ft.*	34 6⅝	95.0334	9 8⅞	592.2481	3.5197
1	34 9¾	96.4783	9 9⅞	601.2529	3.5733
2	35 0⅞	97.9347	9 10¾	610.3290	3.6272
3	35 4⅛	99.4021	9 11⅝	619.4738	3.6815
4	35 7¼	100.8797	10 0½	628.6822	3.7362
5	35 10⅝	102 3689	10 1⅜	637.9629	3.7914
6	36 1½	103.8691	10 2¼	647 3122	3.8470
7	36 4½	105 3794	10 3⅛	656.7244	3.9029
8	36 7¾	106.9013	10 4	666.2089	3.9593
9	36 10⅞	108.4342	10 5	675.7619	4.0160
10	37 2¾	109.9772	10 5⅞	685.3779	4.0732
11	37 5¼	111.5319	10 6¾	695.0668	4.1308
12 *ft.*	37 8⅜	113.0976	10 7⅝	706.8242	4.1888
1	37 11½	114.6732	10 8½	714.6433	4.2471
2	38 2⅝	116.2607	10 9⅜	724.5366	4.3059
3	38 5¾	117.8590	10 10¼	734.4972	4.3651
4	38 8⅞	119.4674	10 11⅛	744 5208	4.4241
5	39 0	121.0876	11 0	754 6179	4.4847
6	39 3¼	122.7187	11 0⅞	764.7829	4.5451
7	39 6⅝	124.3598	11 1⅞	775.0102	4.6059
8	39 9½	126.0127	11 2⅝	785.3111	4.6671
9	40 0⅝	127.6765	11 3⅝	795.6799	4.7287
10	40 3¾	129.3504	11 4½	806.1116	4.7907
11	40 6⅞	131.0360	11 5⅜	816.6163	4.8531

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
13 *ft.*	40 10	132.7326	11 6¼	827.1895	4 9160
1	41 1⅛	134.4391	11 7⅛	837.8244	4 9792
2	41 4⅝	136.1574	11 8⅛	848 5329	5.0428
3	41 7⅛	137 8867	11 8⅞	859.3099	5.1106
4	41 10⅝	139 6260	11 9¾	870.1492	5.1713
5	42 1⅝	141.3771	11 10⅝	881.0620	5.2361
6	42 4⅞	143 1391	11 11⅝	892.0428	5.3014
7	42 8	144 9111	12 0½	907.0859	5.3670
8	42 11⅛	146 6949	12 1⅜	914 2026	5.4331
9	43 2¼	148.4896	12 2¼	923 3871	5.4996
10	43 5½	150 2943	12 3⅛	936.6340	5.5653
11	43 8⅝	152.1109	12 4	947.9551	5.6337
14 *ft.*	43 11¾	153 9384	12 4⅞	959 3441	5 7014
1	44 2⅞	155 7758	12 5⅝	970 7947	5 7694
2	44 6	157.6250	12 6½	982 3190	5.8369
3	44 9⅛	159.4852	12 7½	993 9117	5 9069
4	45 0¼	161.3553	12 8⅜	1005 5662	5 9761
5	45 3½	163.2373	12 9⅜	1017.2958	6.0458
6	45 6⅝	165.1303	12 10¼	1029 0920	6.1159
7	45 9¾	167.0331	12 11⅛	1040 9502	6.1864
8	46 0⅞	168.9479	13 0	1052 8733	6.2573
9	46 4	170 8735	13 1⅛	1064.8846	6.3286
10	46 7⅛	172.8091	13 1¾	1076 9462	6.4410
11	46 11¼	174.7565	13 2⅝	1089 0825	6.4724
15 *ft.*	47 1½	176 7150	13 3½	1101.2878	6 5450
1	47 4⅝	178 6832	13 4⅜	1113 4537	6.6178
2	47 7¾	180.6634	13 5¼	1125 8943	6 6912
3	47 10⅞	182.6545	13 6⅛	1138.3028	6 7649
4	48 2⅛	184 6555	13 7⅛	1149.7730	6 8390
5	48 5⅛	186.6684	13 8	1163.3174	6.9126
6	48 8¼	188.6923	13 8⅞	1172.9304	6 9886
7	48 11⅜	190.7260	13 9¾	1188.6054	7.0639
8	49 2⅝	192.7716	13 10⅝	1201.3626	7.1396
9	49 5¾	194.8282	13 11½	1214.1693	7.2158
10	49 8⅞	196 8946	14 0⅜	1227.0471	7 2923
11	50 0	198 9730	14 1¼	1236 9997	7 3693
16 *ft.*	50 3⅛	201.0624	14 2⅛	1253 0208	7 4467
1	50 6¼	203 1615	14 3	1266.1023	7 5245
2	50 9⅜	205.2726	14 3⅞	1279 2588	7 6026
3	51 0½	207.3946	14 4⅞	1292 4831	7.6812
4	51 3¾	209 5264	14 5¾	1306 7685	7 7602
5	51 6½	211.6703	14 6⅝	1319 1293	7.8396
6	51 10	213 8251	14 7½	1332 5580	7.9194
7	52 1⅛	215 9896	14 8⅜	1346 0471	7.9996
8	52 4¼	218 1662	14 9¼	1359 6138	8 0802
9	52 7⅜	220.3537	14 10⅛	1373 2442	8 1612
10	52 10½	222 5510	14 11	1386.9378	8 2426
11	53 1⅝	224 7603	14 11⅞	1400 7661	8.3444

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
17 *ft.*	53 4⅞	226.9806	15 0¾	1414.5430	8.4067
1	53 8	229.2105	15 1⅝	1428.4398	8.4890
2	53 11⅛	231.4525	15 2⅝	1442.4119	8.5352
3	54 2⅛	233.7055	15 3½	1456.4526	8.6557
4	54 5⅜	235.9682	15 4⅜	1470.5538	8.7395
5	54 8½	238.2430	15 5¼	1484.6303	8.8238
6	54 11⅝	240.5287	15 6⅛	1498.9748	8.9081
7	55 2⅞	242.8241	15 7	1513.2792	8 9234
8	55 6	245.1316	15 7⅞	1527.6601	9.0789
9	55 9⅛	247.4500	15 8¾	1542.1084	9.1648
10	56 0¼	249.7781	15 9⅝	1566.6171	9.2510
11	56 3⅛	252.1184	15 10½	1571.2018	9.3377
18 *ft.*	56 6½	254.4696	15 11⅜	1585.8545	9.4248
1	56 9⅝	256.8303	16 0⅜	1600.5664	9.5122
2	57 0⅞	259.2033	16 1¼	1615.3549	9.6000
3	57 4	261.5872	16 2⅛	1630.2114	9.6884
4	57 7⅛	263.9807	16 3½	1645.1277	9.7252
5	57 10¼	266.3864	16 3⅞	1660.1200	9.8661
6	58 1⅜	268.8031	16 4¾	1675.1809	9.9556
7	58 4½	271.2293	16 5⅝	1690.3009	10.0451
8	58 7⅝	273.6678	16 6½	1705.4977	10.1358
9	58 10¾	276.1171	16 7⅜	1720.7617	10.2264
10	59 2	278.5761	16 8¼	1736.0862	10.3176
11	59 5⅛	281.0472	16 9¼	1751.4861	10.4091
19 *ft.*	59 8¼	283.5294	16 10	1766.9552	10.5011
1	59 11½	286.0210	16 11	1782.4828	10.5933
2	60 2½	288.5249	16 11⅞	1798.0871	10.6861
3	60 5⅝	291.0397	17 0¾	1813.7594	10.7792
4	60 8¾	293.5641	17 1⅝	1829.4914	10.8727
5	60 11⅞	296.1107	17 2½	1845.3005	10.9665
6	61 3⅛	298.6483	17 3⅜	1861.0762	11.0610
7	61 6¼	301.2054	17 4¼	1877.1120	11.1668
8	61 9½	303.7747	17 5⅛	1893.1239	11.2509
9	62 0½	306.3550	17 6	1909.2043	11.3464
10	62 3⅝	308.9448	17 7	1925.3439	11.4424
11	62 6¾	311.5469	17 7⅞	1941.5602	11.5384
20 *ft.*	62 9⅞	314.1600	17 8⅝	1957.8451	11.6355
1	63 1⅛	316.7824	17 9⅝	1974.1879	11.7326
2	63 4¼	319.4173	17 10½	1990.6086	11.8302
3	63 7⅜	322.0630	17 11⅜	2007.0966	11.9282
4	63 11½	324 7182	18 0¼	2023.6438	12.0266
5	64 1⅝	327.3858	18 1⅛	2040.2683	12.1254
6	64 4¾	330.0643	18 2	2056.9607	12.2246
7	64 7⅞	332.7522	18 2⅞	2073.7117	12.3241
8	64 11	335.4525	18 3¾	2090 5399	12.4241
9	65 2¼	338.1637	18 4¾	2107.4361	12.5245
10	65 5⅜	340.8844	18 5⅝	2124.3915	12.6253
11	65 8¼	343.6174	18 6½	2141.4236	12.7265

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
21 *ft.*	65 11⅝	346.3614	18 7¼	2158.5242	12.8282
1	66 2¾	349.1147	18 8¼	2175.6828	12.9301
2	66 5⅞	351.8804	18 9⅛	2192.9186	13.0326
3	66 9	354.6571	18 10	2210.2110	13.1354
4	66 0⅛	357.4432	18 10⅞	2227.5860	13.2386
5	67 3⅜	360.2417	18 11¾	2245.0362	13.3422
6	67 6½	363.0511	19 0⅝	2262.5344	13.4463
7	67 9⅝	365.8698	19 1⅝	2280.1004	13.5507
8	68 0¾	368.7011	19 2⅛	2297.7452	13.6555
9	68 3⅞	371.5432	19 3⅛	2315.4572	13.7608
10	68 7	374.3947	19 4¼	2333.2277	13.8664
11	68 10¼	377.2587	19 5⅛	2351.0762	13.9725
22 *ft.*	69 1⅜	380.1336	19 5⅞	2368.9925	14.0800
1	69 4½	383.0177	19 6⅞	2386.9663	14.1858
2	69 7⅝	385.9144	19 7¾	2405.0185	14.2931
3	69 10¾	388.8220	19 8⅝	2423.1387	14.4008
4	70 1⅞	391.7389	19 9½	2441.3168	14.5088
5	70 5	394.6683	19 10⅜	2458.5728	14.6173
6	70 8¼	397.6087	19 11⅜	2477.9074	14.7262
7	70 11⅜	400.5583	20 0¼	2496.2793	14.8354
8	71 2½	403.5204	20 1⅛	2514.7391	14.9452
9	71 5⅝	406.4935	20 2	2533.2674	15.0558
10	71 8¾	409.4759	20 2⅞	2551.8538	15.1657
11	71 11⅞	412.4707	20 3¾	2570.5174	15.2766
23 *ft.*	72 3	415.4766	20 4½	2589.2501	15.3880
1	72 6⅛	418.4915	20 5⅜	2607.9390	15.4996
2	72 9⅜	421.5192	20 6⅜	2626.9076	15.6118
3	73 0½	424.5577	20 7¼	2645.8435	15.7243
4	73 3⅝	427.6055	20 8⅛	2664.8374	15.8372
5	73 6¾	430.6658	20 9⅛	2683.9092	15.9505
6	73 9⅞	433.7371	20 10	2703.0496	16.0643
7	74 1	436.8175	20 10⅞	2722.2466	16.1784
8	74 4⅛	439.9106	20 11¾	2741.5228	16.2929
9	74 7¼	443.0146	21 0⅝	2760.8669	16.4079
10	74 10⅝	446.1278	21 1½	2780.2684	16.5232
11	75 1⅝	449.2536	21 2⅜	2799.7484	16.6390
24 *ft.*	75 4¾	452.3904	21 3⅛	2819.2969	16.7556
1	75 7⅞	455.5362	21 4⅛	2838.9015	16.8717
2	75 11	458.6948	21 5	2858.5859	16.9886
3	76 2⅛	461.8642	21 6	2878.3376	17.1060
4	76 5¼	465.0428	21 6⅞	2898.1467	17.2608
5	76 8½	468.2341	21 7¾	2918.0349	17.3420
6	76 11⅝	471.4363	21 8⅝	2937.9941	17.4606
7	77 2¾	474.6476	21 9½	2958.0038	17.5795
8	77 5⅞	477.8716	21 10⅜	2978.0958	17.6989
9	77 9	481.1065	21 11¼	2998.2557	17.8187
10	78 0⅛	484.3506	22 0⅛	3018.4729	17.9389
11	78 3¼	487.6073	22 1	3038.8686	18.0619

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
25 *ft.*	78 6⅜	490.8750	22 1⅞	3059.1330	18.1805
1	78 9½	494.1516	22 2¾	3079.5527	18.2385
2	79 0¾	497.4411	22 3¾	3100.0529	18.4237
3	79 3⅞	500.7415	22 4⅝	3120.6210	18.6687
4	79 7⅛	504.0510	22 6½	3141.2458	18.7196
5	79 11⅛	507.3732	22 6⅝	3161.9497	18.7916
6	80 1¼	510.7063	22 7¼	3182.7214	18.9150
7	80 4⅜	514.0484	22 8⅛	3203.5496	19.0388
8	80 7⅝	517.4034	22 9	3224.4579	19.1630
9	80 10¾	520.7692	22 9⅞	3245.4336	19.2877
10	81 1⅞	524.1441	22 10¾	3266.4860	19.4127
11	81 5	527.5318	22 11⅝	3287.6381	19.5382
26 *ft.*	81 8⅛	530 9304	23 0½	3308.7582	19.6640
1	81 11¼	534.3379	23 1½	3329.9937	19.7902
2	82 2⅝	537.7583	23 2⅝	3351.3097	19.9169
3	82 5¼	541.1896	23 3¼	3372.6935	20.0440
4	82 8⅝	544.6299	23 4⅛	3394.1535	20.1714
5	82 11⅞	548.0839	23 5	3415.6532	20.2993
6	83 3	551.5471	23 5⅞	3437.2415	20.4276
7	83 6⅛	555.0201	23 6¾	3458.8852	20.5562
8	83 9¼	558.5059	23 7⅝	3480.6087	20.6854
9	84 0⅜	562.0027	23 8½	3502.3008	20.8149
10	84 3½	565.5084	23 9⅜	3524 2483	20.9447
11	84 6⅝	569.0270	23 10¼	3546.1762	21.0750
27 *ft.*	84 9⅞	572.5566	23 11⅛	3568.1727	21.2058
1	85 1	576.0949	24 0⅛	3590.2234	21.3368
2	85 4¼	579 6463	24 1	3612.3557	21.4683
3	85 8⅛	583.2085	24 1⅞	3634 5553	21.6003
4	85 11⅜	586.7796	24 2¾	3656.8104	21.7325
5	86 1½	590.3637	24 3⅝	3679.1465	21.8653
6	86 4⅝	593.9587	24 4½	3701.5506	21.9984
7	86 7⅞	597.5625	24 5⅜	3724.0094	22.1319
8	86 11	601.1793	24 6¼	3746.5493	22.2569
9	87 2⅛	604.8070	24 7⅛	5769.1572	22.4002
10	87 5¼	608.4436	24 8⅛	3791 8205	22 5349
11	87 8⅜	612.0931	24 9	3814 5641	22.6701
28 *ft.*	87 11⅛	615.7536	24 9¾	3837 3764	22.8056
1	88 2⅝	619.4228	24 10¾	3860.2428	22 9415
2	88 5¾	623.1050	24 11½	3883.1903	23.0779
3	88 9	626.7982	25 0½	3905 4063	23.2147
4	89 0⅛	630.5002	25 1⅜	3929.2772	23.3154
5	89 3¼	634.2152	25 2¼	3952.4291	23.4894
6	89 6⅜	637.9411	25 3⅛	3975 6489	23.6274
7	89 9½	641.6758	25 4	3998 9235	23.7457
8	90 0⅝	645.4235	25 4⅞	4022.4662	23.9045
9	90 3¾	649.1821	25 5⅞	4045 7028	24.0437
10	90 6⅞	652 9495	25 6¾	4069 1813	24.1833
11	90 11⅛	656.7300	25 7⅝	4092.3413	24.3249

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
29 *ft.*	91 1¼	660.5214	25 8⅜	4116 3693	24.4637
1	91 4⅜	664 3214	25 9⅜	4140.0509	24.6044
2	91 7½	668.1346	25 10¼	4163.8148	24.7457
3	91 10⅝	671.9587	25 11⅛	4187.6466	24.8873
4	92 1¾	675 7915	26 0	4211.5326	25 0293
5	92 4⅞	679.6375	26 0⅞	4234.4839	25.1717
6	92 8⅛	683.4943	26 1⅝	4259.5364	25.2405
7	92 11⅛	687.3598	26 2⅝	4283.6263	25 4577
8	93 2⅜	691.2385	26 3⅝	4308 7983	25.6014
9	93 5½	695.1280	26 4½	4332.0376	25.7454
10	93 8⅝	699.0263	26 5⅜	4356.3319	25 8898
11	93 11⅞	702.9377	26 6¼	4380.7077	26.0347
30 *ft.*	94 2⅜	706.8600	26 7	4405.1515	26.1800
1	94 6	710.7909	26 8⅛	4429.6488	26 3255
2	94 9¼	714.7350	26 8⅞	4454.2285	26.4716
3	95 0⅝	718.6900	26 9⅝	4478 8760	26.6181
4	95 3½	722.6537	26 10⅜	4503 5779	26.7649
5	95 6⅝	726.6305	26 11½	4528 3612	26.9122
6	95 9¾	730.6183	27 0⅛	4553.2132	27.0599
7	96 0⅞	734.6147	27 1⅜	4578.1188	27.2079
8	96 4	738.6242	27 2¼	4603.1060	27.3934
9	96 7¼	742.6447	27 3⅛	4628.1617	27.5153
10	96 10⅜	746.6738	27 4	4653.2711	27.6545
11	97 1½	750.7161	27 4⅞	4678 4627	27.8043
31 *ft.*	97 4⅝	754.7694	27 5⅝	4703.7229	27.9544
1	97 7¾	758 8311	27 6⅝	4729.0354	28.1048
2	97 10⅞	762.9062	27 7½	4754.4314	28.2557
3	98 2	766 9921	27 8⅜	4779.8947	28.4070
4	98 5⅛	771.0866	27 9¼	4805.4116	28.5587
5	98 8⅜	775.1944	27 10⅛	4831.0115	28.7109
6	98 11½	779.3131	27 11⅛	4856.6792	28 8634
7	99 2⅝	783.4403	28 0	4882.3999	29.0163
8	99 5¾	787.5808	28 0⅞	4908.2035	29.1696
9	99 8⅞	791.7322	28 1⅜	4934.0750	29.3234
10	100 0	795.8922	28 2⅝	4960.0001	29.4774
11	100 3⅛	800.0654	28 3½	4986.0075	29.6320
32 *ft.*	100 6⅜	804.2496	28 4¼	5012.0835	29.7870
1	100 9½	808.4422	28 5⅛	5038.2117	29.9423
2	101 0⅝	812.6481	28 6⅛	5064.4229	30.0980
3	101 3¾	816 8650	28 7	5090.7026	30.2543
4	101 6⅞	821.0904	28 8	5117.0353	30 4107
5	101 10	825 3291	28 8⅞	5143.4509	30 5677
6	102 1⅛	829.5787	28 9⅝	5169 9344	30 7251
7	102 4⅜	833.8368	28 10⅝	5196 4709	30.8828
8	102 7½	838 1082	28 11½	5223.0903	31.0410
9	102 10⅝	842 3905	29 0⅜	5249.7775	31.1996
10	103 1¾	846 6813	29 1¼	5277.0178	31.3585
11	103 4⅞	850.9855	29 2⅛	5303.3416	31.5179

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
33 *ft.*	103 8	855.3006	29 2⅜	5330.2333	31.6778
1	103 11½	859.6240	29 3⅞	5317.1767	31.8379
2	104 2¼	863 9609	29 4¾	5384.2043	31.9948
3	104 5⅜	868 3087	29 5¾	5411.2998	32.1595
4	104 8⅝	872 6649	29 6⅝	5438.4476	32.3579
5	104 11¾	877.0346	29 7½	5465.6796	32.4827
6	105 2⅞	881.4151	29 8⅜	5492.9789	32.6450
7	105 6	885 8040	29 9¼	5520 3305	32.8075
8	105 9⅛	890.2064	29 10⅛	5547.7662	32.9706
9	106 0¼	894.6196	29 11	5575.2693	33.1340
10	106 3⅜	899.0413	29 11⅞	5602 8253	33.2978
11	106 6⅝	903.4763	30 0⅜	5630.4643	33.4613
34 *ft.*	106 9¾	907.9224	30 1½	5658.1723	33.6267
1	107 0⅞	912.3767	30 2½	5685.9315	33.7917
2	107 4	916.8445	30 3½	5713.7749	33.9572
3	107 7⅛	921.3232	30 4⅝	5741.6861	34.1231
4	107 10¼	925.8103	30 5¼	5769.6497	34.2892
5	108 1⅝	930.3108	30 6⅛	5797.6969	34.4559
6	108 4⅝	934.8223	30 7	5825 8115	34.6230
7	108 7¾	939.3421	30 7⅞	5853.9699	34.7904
8	108 10⅞	943 8753	30 8¾	5882 2308	34.9583
9	109 2	948.4195	30 9⅝	5910.5503	35.1266
10	109 5⅛	652.9720	30 10½	5938 9215	35.2952
11	109 8¼	957.5389	30 11⅜	5967.3768	35.4643
35 *ft.*	109 11⅜	262.1150	31 0¼	5989.9006	35.6339
1	110 2⅝	966.7001	31 1¼	6024.4750	35.8037
2	110 5¾	971.2989	31 2⅛	6053 1347	35.9740
3	110 8⅞	975.9085	31 3	6081.8617	36.1447
4	111 0	980.5264	31 3⅞	6110 6405	36.3158
5	111 3⅛	985.1579	31 4¾	6139.5040	36.4873
6	111 6¼	989.8003	31 5⅝	6168.4354	36.6592
7	111 9⅜	994.4509	31 6½	6197.4180	36.8315
8	112 0½	999.1151	31 7⅜	6226.4833	37.0042
9	112 3¾	1003.7902	31 8¼	6256.6205	37.1404
10	112 6⅞	1008.4736	31 9⅛	6284.8074	37.3509
11	112 10	1013.1705	31 10⅛	6314.0785	37.5248
36 *ft.*	113 1⅛	1017.8784	31 10⅞	6343.4181	37.6992
1	113 4¼	1022.5944	31 11⅞	6372.8083	37.8738
2	113 7⅜	1027.3240	32 0⅜	6403.2831	38.0490
3	113 10⅝	1032.0646	32 1⅝	6431.8265	38.2246
4	114 1¾	1036.8134	32 2½	6461.4211	38.4005
5	114 4⅞	1041.5758	32 3⅜	6491.1003	38 5761
6	114 8	1046.3491	32 4¼	6520 8475	38.7537
7	114 11⅛	1051.1306	32 5⅛	6550 6458	38.9307
8	115 2¼	1055.9257	32 6	6580 5289	39.1083
9	115 5⅜	1060.7317	32 6⅞	6610.4799	39.2863
10	115 9¼	1065 5459	32 7⅞	6640.4820	39.4646
11	115 11⅝	1070.3738	32 8¾	6670.5695	39.6435

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
37 *ft.*	116 2⅜	1075 2126	32 9½	6700.7249	39.8227
1	116 6	1080.0694	32 10½	6730.9301	40.0220
2	116 9⅛	1084.9201	32 11⅝	6762.2220	40.1822
3	117 0¼	1089 7915	33 0¼	6791.5806	40 3626
4	117 3½	1094.6711	33 1⅛	6821.9902	40.5434
5	117 6½	1099.5644	33 2	6852.4853	40.7246
6	117 9⅝	1104.4687	33 2⅞	6883.0489	40.9062
7	118 0¾	1109.3810	33 3¾	6913 6623	41.0882
8	118 4	1114.3071	33 4⅝	6944.3618	41.2706
9	118 7⅛	1119.2440	33 5⅝	6975.1286	41.4535
10	118 10¼	1124.1891	33 6½	7005.9464	41.6366
11	119 1⅜	1129.1478	33 7⅜	7036.8490	41.8203
38 *ft.*	119 4½	1134.1176	33 8⅛	7067 8208	42.0043
1	119 7⅝	1139.0953	33 9⅛	7098.8419	42 1887
2	119 10¾	1144.0868	33 10	7129.9489	42 3736
3	120 2	1149.0892	33 10⅞	7161.1238	42 5588
4	120 5⅛	1154.0997	33 11¾	7192 3493	42.7444
5	120 8⅜	1159 1239	34 0⅝	7223.6601	42.9305
6	120 11⅝	1164.1591	34 1½	7255.0395	43.1459
7	121 2½	1169.2023	34 2⅜	7286.4687	43.3034
8	121 5⅝	1174.2592	34 3⅜	7317.9833	43 4911
9	121 8¾	1179.3271	34 4¼	7349.5664	43.6417
10	121 11⅞	1184.4030	34 5⅛	7381.1994	43.8668
11	122 3⅛	1189.4927	34 6	7412.9185	44.0553
39 *ft.*	122 6¼	1194 5934	34 6¾	7444.7054	44.2442
1	122 9⅜	1199.7195	34 7¾	7476.6519	44.4340
2	123 0⅛	1204.8244	34 8⅛	7478 4626	44.6231
3	123 3⅝	1209 9577	34 9½	7540.4563	44 8123
4	123 6¾	1215 0990	34 10⅜	7572.4969	45.0036
5	123 9⅞	1220 2542	34 11¼	7604.6239	45.1946
6	124 1⅛	1225 4203	35 0⅛	7636.8193	45 3859
7	124 4¼	1230.5943	35 1⅛	7669.0636	45.5775
8	124 7⅜	1235.7822	35 2	7701.3946	45 7697
9	124 10½	1240.9810	35 2⅞	7733.7935	45.9622
10	125 1⅝	1246.1878	35 3¾	7766.2423	46 1551
11	125 4¾	1251.4084	35 4⅝	7798.7771	46.3484
40 *ft.*	125 7⅞	1256.6400	35 5⅝	7831.3804	46 5422
1	125 11	1261.8794	35 6⅝	7864.0324	46 7362
2	126 2¼	1267.1327	35 7¼	7896.7709	46 9308
3	126 5⅝	1272.3970	35 8⅛	7929.5781	47.1257
4	126 8½	1277.6692	35 9	7962.4344	47 3211
5	126 11⅝	1282.9553	35 10	7995.3774	47 5168
6	127 2¾	1288.2523	35 10⅞	8028.2883	47.7130
7	127 5⅞	1293.5572	35 11¾	8061.4484	47 9095
8	127 9	1298 8760	36 0⅛	8094.5952	48 1065
9	128 0¼	1304.2057	36 1½	8127.8099	48 3039
10	128 3⅜	1309.5433	36 2⅜	8161.0738	48.5016
11	128 6½	1314.8949	36 3¼	8194.4250	48.6998

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubicyards at 1 foot in depth.
41 *ft.*	128 9⅝	1320.2574	36 4½	8227.8441	48 8984
1	129 0¾	1325.6276	36 5	8261.3112	49.0973
2	129 3⅞	1331.0119	36 5⅞	8294.8661	49.2967
3	129 7	1336 4071	36 6¾	8328.4890	49.4965
4	129 10⅛	1341.8101	36 7¾	8362.1605	49.6967
	130 1⅜	1347 2271	36 8⅝	8395 9192	49.8973
6	130 4½	1352.6551	36 9½	8429.7465	50 0983
7	130 7⅝	1358.0908	36 10⅜	8463.6218	50.2997
8	130 10¾	1363.5406	36 11¼	8497.5850	50.5015
9	131 1⅞	1369 0012	37 0⅛	8531.6154	50.7037
10	131 5	1374.4697	37 1	8565 6951	50.9063
11	131 8⅛	1379 9521	37 1⅞	8599.8614	51.1093
42 *ft.*	131 11⅜	1385.4456	37 2⅝	8634.0969	51.3128
1	132 2½	1390 2467	37 3⅝	8664.6174	51.4906
2	132 5⅝	1396.4619	37 4½	8702.7505	51.7208
3	132 8¾	1401.9880	37 5½	8737.1892	51.9257
4	132 11⅞	1407.5219	37 6⅜	8771.6764	52.1304
5	133 3	1413 0698	37 7¼	8806.2509	52 3355
6	133 6⅛	1418.6287	37 8⅛	8840.8940	52.5418
7	133 9¼	1424.1952	37 9	8875.5844	52.7479
8	134 0½	1429 7759	37 9⅞	8910 3634	52 9546
9	134 3⅝	1435 3675	37 10¾	8945.2102	53.1618
10	134 6¾	1440.9668	37 11⅝	8980.1050	53 3691
11	134 9⅞	1446.5802	38 0½	9015.0878	53.5770
43 *ft.*	135 1	1452.2046	38 1¼	9050.1390	53.7853
1	135 4⅛	1457.8365	38 2¼	9085 2370	53.9939
2	135 7¼	1463.4827	38 3¼	9120.3741	54.2030
3	135 10½	1469 1397	38 4⅛	9155.6786	54.4126
4	136 1⅝	1474.8044	38 5	9190.9810	54.6224
5	136 4¾	1480 4833	38 5⅞	9226.3719	54.8323
6	136 7⅞	1486.1731	38 6¾	9261.7307	55 0434
7	136 11	1491 8705	38 7⅝	9297.3369	55.2544
8	137 2⅛	1497.5821	38 8½	9332.9316	55 8363
9	137 5¼	1503 3046	38 9⅜	9368 5942	55.6779
10	137 8⅜	1509.0348	38 10¼	9404.3048	55.8902
11	137 11⅝	1514.7791	38 11⅛	9440.1033	56.1029
44 *ft.*	138 2¾	1520.5344	38 11⅞	9475.9703	56.3161
1	138 5⅞	1526.2971	39 1	9511.8835	56.5295
2	138 9	1532.0742	39 1⅞	9547.8864	56.7435
3	139 0⅛	1537.8622	39 2¾	9583.9572	56.9578
4	139 3¼	1543.6578	39 3⅝	9620.0754	57.1725
5	139 6⅜	1549 4776	39 4½	9656.2820	57 3877
6	139 9⅝	1555.2883	39 5⅜	9692.5566	57 6033
7	140 0¾	1561.1165	39 6¼	9728 8780	57.8191
8	140 3⅞	1566.9591	39 7⅛	9765.2891	58.0355
9	140 7½	1572.8125	39 8	9801.7675	58.2523
10	140 10⅛	1578.6735	39 8⅞	9838.2932	58.4323
11	141 1¼	1584.5488	39 9¾	9874.9081	58.6499

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of — square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
45 *ft.*	141 $4^{3}/_{8}$	1590.4350	39 $10^{1}/_{2}$	9911.5909	58.9050
1	141 $7^{1}/_{2}$	1596.3286	39 $11^{5}/_{8}$	9948.3198	59.1233
2	141 $10^{3}/_{4}$	1602.2366	40 $0^{1}/_{2}$	9985.1384	59.3421
3	142 $1^{7}/_{8}$	1608.1555	40 $1^{3}/_{8}$	10022.025	59.5613
4	142 5	1614.0819	40 $2^{1}/_{4}$	10058.958	59.7808
5	142 $8^{1}/_{8}$	1620.0226	40 $3^{1}/_{8}$	10095.980	60.0008
6	142 $11^{1}/_{4}$	1625.9743	40 4	10133.071	60.2212
7	143 $2^{3}/_{8}$	1631.9334	40 $4^{7}/_{8}$	10170.208	60.4420
8	143 $5^{1}/_{2}$	1637.9068	40 $5^{3}/_{4}$	10207.435	60.6632
9	143 $8^{3}/_{4}$	1643.8912	40 $6^{5}/_{8}$	10244.729	60.8848
10	143 $11^{7}/_{8}$	1649.8831	40 $7^{5}/_{8}$	10277.070	61.1068
11	144 3	1655.8892	40 $8^{1}/_{2}$	10319.501	61.3292
46 *ft.*	144 $6^{1}/_{8}$	1661.9064	40 $9^{1}/_{8}$	10357.000	61.5521
1	144 $9^{1}/_{4}$	1667.9308	40 $10^{1}/_{4}$	10394.544	61.7752
2	145 $0^{3}/_{8}$	1673.9698	40 $11^{1}/_{8}$	10432.179	61.9989
3	145 $3^{1}/_{2}$	1680.0196	41 0	10469.880	62.2229
4	145 $6^{5}/_{8}$	1686.0769	41 $0^{7}/_{8}$	10507.631	62.4473
5	145 $9^{7}/_{8}$	1692.1485	41 $1^{3}/_{4}$	10546.469	62.6722
6	146 $1^{1}/_{8}$	1698.2311	41 $2^{5}/_{8}$	10583.376	62.8974
7	146 $4^{1}/_{8}$	1704.3210	41 $3^{1}/_{2}$	10621.328	63.1230
8	146 $7^{1}/_{4}$	1710.4254	41 $4^{3}/_{8}$	10659.371	63.3491
9	146 $10^{3}/_{8}$	1716.5407	41 $5^{3}/_{8}$	10697.481	63.5756
10	147 $1^{1}/_{2}$	1722.6634	41 $6^{1}/_{4}$	10735.638	63.8021
11	147 $4^{5}/_{8}$	1728.8005	41 $7^{1}/_{8}$	10773.884	64.0296
47 *ft.*	147 $7^{3}/_{4}$	1734.9486	41 $7^{3}/_{4}$	10812.199	64.2573
1	147 11	1741.1039	41 $8^{7}/_{8}$	10850.559	64.4853
2	148 $2^{1}/_{8}$	1747.2738	41 $9^{3}/_{4}$	10889.010	64.7138
3	148 $5^{1}/_{4}$	1753.4545	41 $10^{5}/_{8}$	10927.528	64.9427
4	148 $8^{3}/_{8}$	1759.6426	41 $11^{1}/_{2}$	10966.092	65.1719
5	148 $11^{1}/_{2}$	1765.8452	42 $0^{3}/_{8}$	11004.747	65.4017
6	149 $2^{5}/_{8}$	1772.0587	42 $1^{1}/_{4}$	11043.469	65.6318
7	149 $5^{7}/_{8}$	1778.2795	42 $2^{1}/_{8}$	11082.237	65.8622
8	149 $8^{7}/_{8}$	1784.5148	42 $3^{1}/_{8}$	11121.096	66.0931
9	150 $0^{1}/_{8}$	1790.7610	42 4	11160.022	66.3245
10	150 $3^{1}/_{4}$	1797.0145	42 $4^{7}/_{8}$	11197.994	66.5561
11	150 $6^{3}/_{8}$	1803.2826	42 $5^{3}/_{4}$	11238.057	66.7882
48 *ft.*	150 $9^{1}/_{2}$	1809.5616	42 $6^{1}/_{2}$	11287.187	67.0208
1	151 $0^{5}/_{8}$	1815.8477	42 $7^{1}/_{8}$	11316.362	67.2536
2	151 $3^{3}/_{4}$	1822.1485	42 $8^{3}/_{8}$	11336.629	67.4870
3	151 $6^{7}/_{8}$	1828.4602	42 $9^{1}/_{4}$	11394.963	67.7209
4	151 $10^{1}/_{8}$	1834.7791	42 $10^{1}/_{8}$	11434.343	67.9548
5	152 $1^{1}/_{4}$	1841.1127	42 11	11473.814	68.1893
6	152 $4^{3}/_{8}$	1847.4571	43 0	11513.352	68.4243
7	152 $7^{1}/_{2}$	1853.8087	43 $0^{7}/_{8}$	11552.935	68.6560
8	152 $10^{5}/_{8}$	1860.1750	43 $1^{3}/_{4}$	11592.610	68.8953
9	153 $1^{3}/_{4}$	1866.5521	43 $2^{5}/_{8}$	11632.352	69.1315
10	153 $4^{7}/_{8}$	1872.9365	43 $3^{1}/_{2}$	11672.140	69.3680
11	153 $8^{1}/_{8}$	1879.3355	43 $4^{3}/_{8}$	11712.018	69.6050

Dia. in feet & inches.	Circum. in feet and inches.	Area in feet.	Side of square in ft. and in.	Gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
49 *ft.*	153 $11\frac{1}{4}$	1885.7454	43 $5\frac{1}{8}$	11750.964	69.8424
1	154 $2\frac{3}{8}$	1892.1724	43 $6\frac{1}{8}$	11792.018	70.0804
2	154 $5\frac{1}{2}$	1898.5041	43 7	11831.477	70.3150
3	154 $8\frac{5}{8}$	1905.0367	43 $7\frac{7}{8}$	11872.188	70.5569
4	154 $11\frac{7}{8}$	1911.4965	43 $8\frac{3}{4}$	11912.446	70.7961
5	155 $2\frac{7}{8}$	1917.9609	43 $9\frac{3}{4}$	11952.732	71.0356
6	155 6	1924.4263	43 $10\frac{5}{8}$	11993.824	71.2750
7	155 $9\frac{1}{4}$	1930.9188	43 $11\frac{1}{2}$	12033.485	71.5155
8	156 $0\frac{1}{8}$	1937.3159	44 $0\frac{3}{8}$	12073.352	71.7524
9	156 $3\frac{1}{2}$	1943.9140	44 $1\frac{1}{4}$	12114.472	71.9968
10	156 $6\frac{5}{8}$	1950.4392	44 $2\frac{1}{8}$	12155.137	72.2385
11	156 $9\frac{3}{4}$	1956.9691	44 3	12195.831	72.4803
50 *ft.*	157 $0\frac{7}{8}$	1963.5000	44 $3\frac{3}{4}$	12236.532	72.7222

TABLE

CONTAINING

THE SQUARE & CUBE ROOTS OF ALL NUMBERS

From 1 *to* 1000; *and the*

DIFFERENCE EXISTING BETWEEN EACH ROOT,

BY WHICH

The process for obtaining the roots of numbers, consisting of integers and decimals, is considerably facilitated.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given, the sum is the root required.

EXAMPLE 1.—Required the square root of 53.75.

Difference by table = .0683 × .75 = .051225, and the root of 53 = 7.2801,—hence, 7.2801 + .051225 = 7.3313, the root required.

EXAMPLE 2.—Required the cube root of the number 734.26.

Difference by table = .0041 × .26 = .001066, and the root of 734 = 9.0205,—hence, 9.0205 + .001066 = 9.0215, the root required.

TABLE

Containing the Square and Cube Roots of all Numbers from 1 *to* 1000, *&c.*

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
1	1.0000	4142	1.0000	.2599	45	6 7082	.0741	3.5568	.0262
2	1 4142	3178	1.2599	.1823	46	6 7823	0733	3 5830	.0258
3	1 7320	.2680	1.4422	.1452	47	6 8556	0726	3 6088	0254
4	2 0000	.2360	1.5874	.1225	48	6 9282	0718	3 6342	.0251
5	2 2360	.2134	1.7099	.1072	49	7 0000	0710	3 6593	.0247
6	2.4494	.1963	1 8171	.0950	50	7 0710	0704	3 6840	.0244
7	2 6457	1827	1 9129	.0871	51	7 1414	.0697	3 7084	.0241
8	2 8284	.1716	2.0000	.0800	52	7 2111	.0690	3 7325	.0237
9	3 0000	.1622	2 0800	.0744	53	7 2801	.0683	3.7562	.0236
10	3 1622	.1544	2.1544	.0685	54	7 3484	.0677	3.7797	.0232
11	3 3166	.1475	2.2239	.0655	55	7.4161	.0672	3 8029	.0229
12	3 4641	.1414	2 2894	.0619	56	7.4833	0665	3 8258	.0227
13	3 6055	.1361	2 3513	.0588	57	7 5498	.0659	3 8485	.0223
14	3 7416	.1313	2 4101	.0551	58	7.6157	.0654	3 8708	.0221
15	3.8729	.1271	2 4662	.0536	59	7.6811	.0648	3.8929	.0219
16	4.0000	.1231	2.5198	.0514	60	7 7459	0643	3 9148	.0216
17	4.1231	.1195	2 5712	.0595	61	7.8102	.0638	3 9364	.0214
18	4.2426	.1162	2.6207	.0477	62	7.8740	.0632	2.9578	.0212
19	4.3588	.1133	2 6684	0460	63	7 9372	.0628	3.9790	.0210
20	4 4721	.1104	2 7144	.0445	64	8.0000	.0622	4.0000	.0207
21	4.5825	.1079	2 7589	0431	65	8.0622	.0618	4.0207	.0205
22	4.6904	.1054	2 8020	0418	66	8.1240	.0613	4 0412	.0203
23	4.7958	.1031	2 8438	.0406	67	8.1853	.0609	4 0615	.0201
24	4.8989	.1011	2 8844	.0396	68	8.2462	.0604	4 0816	.0199
25	5.0000	.0990	2 9240	.0384	69	8 3066	.0600	4.1015	.0197
26	5.0990	.0971	2 9624	.0376	70	8.3666	.0595	4.1212	.0196
27	5.1961	.0954	3 0000	.0365	71	8.4261	.0591	4.1408	.0193
28	5.2915	0936	3.0365	.0358	72	8.4852	.0588	4.1601	.0192
29	5.3851	0921	3 0723	.0349	73	8 5440	.0583	4.1793	.0190
30	5.4772	.0905	3.1072	.0341	74	8 6023	.0579	4.1983	.0188
31	5 5677	0891	3 1413	0325	75	8 6602	.0565	4.2171	.0187
32	5 6563	0877	3 1748	0327	76	8 7177	.0572	4 2358	.0185
33	5 7445	0864	3 2075	0321	77	8.7749	.0568	4.2543	.0183
34	5 8309	0851	3.2396	.6314	78	8 8317	.0564	4.2726	.0182
35	5 9160	0840	3 2710	.0309	79	8 8881	.0561	4.2908	.0180
36	6.0000	0827	3 3019	0303	80	8 9442	.0558	4 3088	.0179
37	6.0827	0817	3 3322	0297	81	9 0000	.0553	4.3267	.0177
38	6.1644	0805	3 3619	.0293	82	9 0553	.0551	4.3444	.0176
39	6.2449	0796	3 3912	.0287	83	9.1104	.0547	4.3620	.0175
40	6 3245	0786	3 4199	.0283	84	9.1651	.0544	4 3795	.0173
41	6.4031	0776	3.4482	.0278	85	9 2195	.0541	4 3968	.0172
42	6 4807	0767	3 4760	0273	86	9.2736	.0537	4 4140	.0170
43	6 5574	0758	3 5033	0270	87	9.3273	.0535	4.4310	.0169
44	6.6332	0750	3 5303	0265	88	9 3808	.0531	4.4479	.0168
45	6 7082		3 5568		89	9.4339		4.4647	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
89	9.4339	.0529	4.4647	.0167	137	11.7046	.0427	5.1551	.0125
90	9.4868	.0525	4.4814	.0165	138	11.7473	.0425	5.1676	.0125
91	9.5393	.0523	4.4979	.0164	139	11.7898	.0423	5.1801	.0123
92	9.5916	.0520	4.5143	.0163	140	11.8321	.0422	5.1924	.0124
93	9.6436	.0517	4.5306	.0162	141	11.8743	.0420	5.2048	.0123
94	9.6953	.0514	4.5468	.0161	142	11.9163	.0419	5.2171	.0122
95	9.7467	.0512	4.5629	.0159	143	11.9582	.0418	5.2293	.0121
96	9.7979	.0589	4.5788	.0159	144	12.0000	.0415	5.2414	.0121
97	9.8488	.0506	4.5947	.0157	145	12.0415	.0414	5.2535	.0121
98	9.8994	.0504	4.6104	.0156	146	12.0830	.0413	5.2656	.0120
99	9.9498	.0502	4.6260	.0155	147	12.1243	.0412	5.2776	.0119
100	10.0000	.0498	4.6415	.0155	148	12.1655	.0410	5.2895	.0119
101	10.0498	.0497	4.6570	.0153	149	12.2065	.0409	5.3014	.0118
102	10.0995	.0493	4.6723	.0153	150	12.2474	.0408	5.3132	.0118
103	10.1488	.0492	4.6875	.0151	151	12.2882	.0406	5.3250	.0118
104	10.1980	.0489	4.7026	.0150	152	12.3288	.0405	5.3368	.0116
105	10.2469	.0487	4.7176	.0150	153	12.3693	.0403	5.3484	.0117
106	10.2956	.0484	4.7326	.0148	154	12.4096	.0402	5.3601	.0115
107	10.3440	.0483	4.7474	.0148	155	12.4498	.0401	5.3716	.0116
108	10.3923	.0480	4.7622	.0146	156	12.4899	.0400	5.3832	.0114
109	10.4403	.0477	4.7768	.0146	157	12.5299	.0399	5.3946	.0115
110	10.4880	.0476	4.7914	.0144	158	12.5698	.0397	5.4061	.0114
111	10.5356	.0474	4.8058	.0144	159	12.6095	.0396	5.4175	.0113
112	10.5830	.0471	4.8202	.0143	160	12.6491	.0394	5.4288	.0113
113	10.6301	.0469	4.8345	.0143	161	12.6885	.0394	5.4401	.0112
114	10.6770	.0468	4.8488	.0141	162	12.7279	.0392	5.4513	.0112
115	10.7238	.0465	4.8629	.0140	163	12.7671	.0391	5.4625	.0112
116	10.7703	.0463	4.8769	.0140	164	12.8062	.0390	5.4737	.0111
117	10.8166	.0461	4.8909	.0139	165	12.8452	.0389	5.4848	.0110
118	10.8627	.0460	4.9048	.0138	166	12.8840	.0388	5 4958	.0110
119	10.9087	.0467	4.9186	.0138	167	12.9228	.0387	5.5068	.0110
120	10.9544	.0456	4.9324	.0136	168	12.9614	.0386	5.5178	.0109
121	11.0000	.0453	4.9460	.0136	169	13.0000	.0384	5.5287	.0109
122	11.0453	.0452	4 9596	.0135	170	13.0384	.0382	5.5396	.0108
123	11.0905	.0450	4.9731	.0135	171	13.0766	.0382	5.5504	.0108
124	11.1355	.0448	4.9866	.0134	172	13.1148	.0381	5.5612	.0108
125	11.1803	.0446	5.0000	.0132	173	13.1529	.0380	5.5720	.0107
126	11.2249	.0445	5.0132	.0133	174	13.1909	.0378	5.5827	.0107
127	11.2694	.0443	5.0265	.0131	175	13.2287	.0377	5.5934	.0106
128	11.3137	.0441	5.0396	.0131	176	13.2664	.0376	5.6040	.0106
129	11.3578	.0439	5.0527	.0130	177	13 3041	.0375	5.6146	.0106
130	11.4017	.0438	5.0657	.0130	178	13.3416	.0374	5.6252	.0105
131	11 4455	.0436	5.0787	.0129	179	13.3790	.0373	5.6357	.0105
132	11.4891	.0434	5.0916	.0128	180	13.4164	.0372	5.6462	.0104
133	11.5325	.0433	5.1044	.0128	181	13.4536	.0371	5.6566	.0104
134	11.5758	.0431	5.1172	.0127	182	13.4907	.0370	5.6670	.0104
135	11.6189	.0430	5.1299	.0126	183	13.5277	.0369	5.6774	.0103
136	11.6619	.0428	5.1425	.0126	184	13.5646	.0368	5.6877	.0103
137	11.7046		5.1551		185	13.6014		5.6980	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
185	13.6014	.0367	5.6980	.0102	233	15.2643	.0327	6.1534	.0088
186	13.6381	.0366	5.7082	.0102	234	15.2970	.0327	6.1622	.0088
187	13 6747	.0365	5 7184	.0102	235	15.3297	.0325	6.1710	.0088
188	13.7113	.0364	5 7286	.0101	236	15.3622	.0326	6.1797	.0087
189	13.7477	.0363	5.7387	.0101	237	15.3948	.0324	6.1884	.0087
190	13 7840	.0362	5.7488	.0101	238	15.4272	.0324	6.1971	.0087
191	13 8202	.0361	5.7589	.0100	239	15.4596	.0323	6.2058	.0086
192	13 8564	.0360	5.7689	.0100	240	15.4919	.0322	6.2144	.0086
193	13 8924	.0359	5.7789	.0100	241	15.5241	.0322	6.2230	.0086
194	13 9283	.0358	5.7889	.0099	242	15.5563	.0321	6.2316	.0086
195	13.9642	.0357	5.7988	.0099	243	15.5884	.0320	6.2402	.0086
196	14.0000	.0356	5 8087	.0099	244	15.6204	.0320	6.2487	.0085
197	14.0356	.0356	5.8186	.0098	245	15.6524	.0319	6.2573	.0086
198	14 0712	.0355	5.8284	.0098	246	15.6843	.0319	6.2658	.0085
199	14.1067	.0354	5.8382	.0098	247	15 7162	.0318	6.2743	.0085
200	14.1421	.0353	5.8480	.0097	248	15.7480	.0317	6.2827	.0084
201	14.1774	.0352	5 8577	.0097	249	15.7797	.0316	6.2911	.0084
202	14.2126	.0351	5.8674	.0097	250	15.8113	.0316	6.2996	.0085
203	14.2478	.0350	5.8771	.0096	251	15.8429	.0316	6.3079	.0083
204	14.2828	.0350	5 8867	.0096	252	15.8745	.0314	6.3163	.0084
205	14.3178	.0349	5.8963	.0096	253	15.9059	.0314	6.3247	.0084
206	14.3527	.0348	5 9059	.0095	254	15 9373	.0314	6.3330	.0083
207	14.3874	.0347	5.9154	.0095	255	15.9687	.0313	6 3413	.0083
208	14.4222	.0346	5.9249	.0095	256	16.0000	.0312	6.3496	.0083
209	14.4568	.0345	5.9344	.0095	257	16.0312	.0311	6.3578	.0082
210	14.4913	.0345	5.9439	.0094	258	16.0623	.0311	6.3660	.0083
211	14 5258	.0344	5.9533	.0094	259	16.0934	.0311	6.3743	.0082
212	14.5602	.0343	5.9627	.0093	260	16.1245	.0309	6 3825	.0081
213	14.5945	.0342	5.9720	.0094	261	16.1554	.0310	6 3906	.0082
214	14.6287	.0341	5.9814	.0093	262	16.1864	.0308	6.3988	.0081
215	14.6628	.0341	5.9907	.0093	263	16.2172	.0308	6.4069	.0081
216	14 6969	.0340	6.0000	.0093	264	16.2480	.0308	6.4150	.0081
217	14 7309	.0339	6.0092	.0092	265	16.2788	.0307	6.4231	.0081
218	14.7648	.0338	6.0184	.0092	266	16.3095	.0306	6.4312	.0080
219	14 7986	.0337	6.0276	.0092	267	16.3401	.0306	6.4392	.0081
220	14.8323	.0337	6.0368	.0091	268	16.3707	.0305	6.4473	.0080
221	14.8660	.0336	6 0459	.0091	269	16 4012	.0304	6.4553	.0080
222	14.8996	.0335	6.0550	.0091	270	16.4316	.0304	6.4633	.0078
223	14 9331	.0335	6 0641	.0090	271	16.4620	.0304	6.4712	.0080
224	14 9666	.0334	6.0731	.0091	272	16.4924	.0303	6.4792	.0079
225	15 0000	.0332	6.0822	.0089	273	16.5227	.0302	6.4871	.0079
226	15 0332	.0333	6.0911	.0090	274	16.5529	.0302	6.4950	.0079
227	15.0665	.0331	6.1001	.0090	275	16.5831	.0301	6.5029	.0079
228	15 0996	.0331	6.1091	.0089	276	16 6132	.0301	6.5108	.0078
229	15.1327	.0330	6.1180	.0089	277	16.6433	.0300	6 5186	.0079
230	15.1657	.0329	6 1269	.0088	278	16 6733	.0299	6.5265	.0078
231	15.1986	.0329	6.1357	.0089	279	16 7032	.0300	6 5343	.0078
232	15 2315	.0328	6.1446	.0088	280	16.7332	.0298	6.5421	.0078
233	15 2643		6.1534		281	16.7630		6 5499	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
281	16.7630	.0298	6.5499	.0077	329	18.1383	.0276	6.9034	.0070
282	16.7928	.0298	6.5576	.0078	330	18.1659	.0275	6.9104	.0069
283	16.8226	.0296	6.5654	.0077	331	18.1934	.0274	6.9173	.0070
284	16.8522	.0297	6.5731	.0077	332	18.2208	.0274	6.9243	.0070
285	16.8819	.0296	6.5808	.0077	333	18.2482	.0274	6.9313	.0070
286	16.9115	.0295	6.5885	.0077	334	18.2756	.0274	6.9383	.0068
287	16.9410	.0295	6.5962	.0076	335	18.3030	.0273	6.9451	.0069
288	16.9705	.0295	6.6038	.0076	336	18.3303	.0272	6.9520	.0069
289	17.0000	.0293	6.6114	.0077	337	18.3575	.0272	6.9589	.0069
290	17.0293	.0294	6.6191	.0076	338	18.3847	.0272	6.9658	.0068
291	17.0587	.0293	6.6267	.0075	339	18.4119	.0272	6.9726	.0069
292	17.0880	.0292	6.6342	.0076	340	18.4390	.0271	6.9795	.0068
293	17.1172	.0292	6.6418	.0075	341	18.4661	.0271	6.9863	.0068
294	17.1464	.0291	6.6493	.0076	342	18.4932	.0271	6.9931	.0069
295	17.1755	.0291	6.6569	.0075	343	18.5202	.0270	7.0000	.0067
296	17.2046	.0290	6.6644	.0075	344	18.5472	.0269	7.0067	.0068
297	17.2336	.0290	6.6719	.0075	345	18.5741	.0269	7.0135	.0068
298	17.2626	.0290	6.7694	.0074	346	18.6010	.0269	7.0203	.0068
299	17.2916	.0289	6.8668	.0075	347	18.6279	.0268	7.0271	.0067
300	17.3205	.0288	6.6943	.0074	348	18.6547	.0268	7.0338	.0067
301	17.3493	.0288	6.7017	.0074	349	18.6815	.0267	7.0405	.0067
302	17.3781	.0287	6 7091	.0074	350	18.7082	.0267	7.0472	.0068
303	17.4068	.0287	6 7165	.0074	351	18.7349	.0267	7.0540	.0066
304	17.4355	.0287	6 7239	.0074	352	18.7616	.0266	7.0606	.0067
305	17.4642	.0286	6.7313	.0073	353	18.7882	.0266	7.0673	.0067
306	17.4928	.0286	6 7386	.0073	354	18.8148	.0266	7.0740	.0066
307	17.5214	.0285	6.7459	.0074	355	18 8414	.0265	7.0806	.0067
308	17.5499	.0284	6 7533	.0073	356	18.8679	.0265	7.0873	.0066
309	17.5783	.0285	6.7606	.0072	357	18.8944	.0264	7.0939	.0066
310	17.6068	.0283	6 7678	.0073	358	18.9208	.0264	7.1005	.0066
311	17.6351	.0284	6 7751	.0073	359	18.9472	.0264	7.1071	.0066
312	17.6635	.0283	6.7824	.0072	360	18 9736	.0264	7.1137	.0066
313	17.6918	.0282	6.7896	.0072	361	19.0000	.0262	7.1203	.0066
314	17.7200	.0282	6.7968	.0072	362	19.0262	.0263	7.1269	.0065
315	17.7482	.0281	6 8040	.0072	363	19.0525	.0262	7.1334	.0066
316	17 7763	.0281	6.8112	.0072	364	19.0787	.0262	7.1400	.0065
317	17 8044	.0281	6 8184	.0072	365	19.1049	.0262	7.1465	.0065
318	17 8325	.0280	6.8256	.0071	366	19.1311	.0261	7.1530	.0065
319	17.8605	.0280	6.8327	.0072	367	19.1572	.0261	7.1595	.0065
320	17.8885	.0279	6 8399	.0071	368	19.1833	.0260	7.1660	.0065
321	17 9164	.0279	6 8470	.0071	369	19.2093	.0260	7.1725	.0065
322	17.9443	.0279	6 8541	.0071	370	19.2353	.0260	7.1790	.0065
323	17 9722	.0278	6.8612	.0070	371	19.2613	.0260	7.1855	.0064
324	18.0000	.0277	6.8682	.0071	372	19.2873	.0259	7.1919	.0065
325	18.0277	.0277	6.8753	.0070	373	19.3132	.0258	7.1984	.0064
326	18.0554	.0277	6.8823	.0071	374	19 3390	.0259	7.2048	.0064
327	18.0831	.0276	6.8894	.0070	375	19.3649	.0258	7.2112	.0064
328	18.1107	.0276	6 8964	.0070	376	19.3907	.0257	7.2176	.0064
329	18.1383		6.9034		377	19.4164		7.2240	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
377	19.4164	.0258	7.2240	.0064	425	20.6155	.0242	7.5184	.0059
378	19.4422	.0257	7.2304	.0063	426	20.6397	.0242	7.5243	.0059
379	19.4679	.0256	7.2367	.0064	427	20.6639	.0242	7.5302	.0059
380	19.4935	.0257	7.2431	.0064	428	20.6881	.0242	7.5361	.0058
381	19.5192	.0256	7.2495	.0063	429	20.7123	.0241	7.5419	.0059
382	19.5448	.0255	7.2558	.0063	430	20.7364	.0241	7.5478	.0058
383	19.5703	.0256	7.2621	.0063	431	20.7605	.0241	7.5536	.0059
384	19.5959	.0255	7.2684	.0063	432	20.7846	.0240	7.5595	.0058
385	19.6214	.0254	7.2747	.0063	433	20.8086	.0240	7.5653	.0058
386	19.6468	.0255	7.2810	.0063	434	20.8326	.0240	7.5711	.0058
387	19.6723	.0254	7.2873	.0063	435	20.8566	.0240	7.5769	.0058
388	19.6977	.0253	7.2936	.0062	436	20.8806	.0239	7.5827	.0058
389	19.7230	.0254	7.2998	.0063	437	20.9045	.0239	7.5885	.0058
390	19.7484	.0253	7.3061	.0062	438	20.9284	.0239	7.5943	.0058
391	19.7737	.0252	7.3123	.0063	439	20.9523	.0238	7.6001	.0058
392	19.7989	.0253	7.3186	.0062	440	20.9761	.0239	7.6059	.0057
393	19.8242	.0252	7.3248	.0062	441	21.0000	.0237	7.6116	.0058
394	19.8494	.0252	7.3310	.0062	442	21.0237	.0220	7.6174	.0057
395	19.8746	.0251	7.3372	.0062	443	21.0457	.0256	7.6231	.0057
396	19.8997	.0251	7.3434	.0061	444	21.0713	.0237	7.6288	.0058
397	19.9248	.0251	7.3495	.0062	445	21.0950	.0237	7.6346	.0057
398	19.9499	.0250	7.3557	.0062	446	21.1187	.0236	7.6403	.0057
399	19.9749	.0251	7.3619	.0061	447	21.1423	.0237	7.6460	.0057
400	20.0000	.0249	7.3680	.0061	448	21.1660	.0236	7.6517	.0057
401	20.0249	.0240	7.3741	.0062	449	21.1896	.0236	7.6574	.0056
402	20.0499	.0249	7.3803	.0061	450	21.2132	.0225	7.6630	.0057
403	20.0748	.0249	7.3864	.0061	451	21.2367	.0235	7.6687	.0057
404	20.0997	.0249	7.3925	.0061	452	21.2602	.0235	7.6744	.0056
405	20.1246	.0248	7.3986	.0061	453	21.2837	.0235	7.6800	.0057
406	20.1494	.0248	7.4047	.0060	454	21.3072	.0235	7.6857	.0056
407	20.1742	.0248	7.4107	.0061	455	21.3307	.0234	7.6913	.0057
408	20.1990	.0247	7.4168	.0061	456	21.3541	.0234	7.6970	.0056
409	20.2237	.0247	7.4229	.0060	457	21.3775	.0234	7.7026	.0056
410	20.2484	.0247	7.4289	.0060	458	21.4009	.0233	7.7082	.0056
411	20.2731	.0246	7.4349	.0061	459	21.4242	.0234	7.7138	.0056
412	20.2977	.0247	7.4410	.0060	460	21.4476	.0233	7.7194	.0056
413	20.3224	.0245	7.4470	.0060	461	21.4709	.0232	7.7250	.0056
414	20.3469	.0246	7.4530	.0060	462	21.4941	.0233	7.7306	.0055
415	20.3715	.0245	7.4590	.0060	463	21.5174	.0232	7.7361	.0056
416	20.3960	.0245	7.4650	.0059	464	21.5406	.0232	7.7417	.0056
417	20.4205	.0245	7.4709	.0060	465	21.5638	.0232	7.7473	.0055
418	20.4450	.0244	7.4769	.0060	466	21.5870	.0231	7.7528	.0056
419	20.4694	.0245	7.4829	.0059	467	21.6101	.0232	7.7584	.0055
420	20.4939	.0243	7.4888	.0060	468	21.6333	.0231	7.7639	.0055
421	20.5182	.0244	7.4948	.0059	469	21.6564	.0230	7.7694	.0055
422	20.5426	.0243	7.5007	.0059	470	21.6794	.0231	7.7749	.0055
423	20.5669	.0243	7.5066	.0059	471	21.7025	.0230	7.7804	.0055
424	20.5912	.0243	7.5125	.0059	472	21.7255	.0230	7.7859	.0055
425	20.6155		7.5184		473	21.7485		7.7914	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
473	21.7485		7.7914		521	22.8254		8 0466	
		.0230		.0055			.0219		.0051
474	21.7715		7 7969		522	22.8473		8 0517	
		.0229		.0055			.0218		.0051
475	21.7944		7.8024		523	22 8691		8 0568	
		.0230		.0055			.0219		.0052
476	21.8174		7 8079		524	22.8910		8 0620	
		.0229		.0055			.0218		.0051
477	21.8403		7 8133		525	22.9128		8 0671	
		.0229		.0054			.0218		.0051
478	21.8632		7 8188		526	22.9346		8 0722	
		.0228		.0055			.0218		.0051
479	21.8860		7.8242		527	22.9564		8.0773	
		.0229		.0054			.0218		.0051
480	21 9089		7 8297		528	22 9782		8 0824	
		.0228		.0055			.0218		.0051
481	21 9317		7 8351		529	23 0000		8.0875	
		.0227		.0054			.0217		.0051
482	21.9544		7 8405		530	23.0217		8 0926	
		.0228		.0054			.0217		.0051
483	21.9772		7.8460		531	23.0434		8 0977	
		.0228		.0055			.0217		.0051
484	22.0000		7.8514		532	23.0651		8.1028	
		.0227		.0054			.0216		.0051
485	22 0227		7.8568		533	23 0867		8.1079	
		.0227		.0054			.0217		.0050
486	22.0454		7 8622		534	23.1084		8 1129	
		.0226		.0054			.0216		.0051
487	23.0680		7.8676		535	23.1300		8 1180	
		.0227		.0054			.0216		.0050
488	22 0907		7 8729		536	23 1516		8.1230	
		.0226		.0053			.0216		.0051
489	22.1133		7.8783		537	23.1732		8.1281	
		.0226		.0054			.0216		.0050
490	22.1359		7.8837		538	23.1948		8.1331	
		.0226		.0054			.0215		.0051
491	22.1585		7.8890		539	23.2163		8.1382	
		.0225		.0053			.0216		.0050
492	22.1810		7 8944		540	23 2379		8.1432	
		.0226		.0054			.0215		.0050
493	22 2036		7 8997		541	23.2594		8.1482	
		.0225		.0053			.0214		.0050
494	22.2261		7.9051		542	23 2808		8.1532	
		.0224		.0054			.0215		.0051
495	22.2485		7.9104		543	23.3023		8.1583	
		.0225		.0053			.0215		.0050
496	22.2710		7.9157		544	23 3238		8.1633	
		.0224		.0053			.0214		.0050
497	22.2934		7.9210		545	23 3452		8.1683	
		.0225		.0053			.9214		.0050
498	22.3159		7.9264		546	23.3666		8.1733	
		.0224		.0054			.0214		.0049
499	22.3383		7.9317		547	23.3880		8.1782	
		.0223		.0053			.0213		.0050
500	22 3606		7.9370		548	23.4093		8.1832	
		.0224		.0052			.0214		.0050
501	22.3830		7.9422		549	23.4307		8.1882	
		.0223		.0053			.0213		.0050
502	22.4053		7.9475		550	23 4520		8 1932	
		.0223		.0053			.0213		.0049
503	22.4276		7.9528		551	23.4633		8 1981	
		.0223		.0053			.0213		.0050
504	22.4499		7.9581		552	23.4946		8.2031	
		.0223		.0052			.0213		.0049
505	22.4722		7.9633		553	23.5159		8.2080	
		.0222		.0053			.0213		.0050
506	22 4944		7.9686		554	23.5372		8 2130	
		.0222		.0052			.0212		.0049
507	22 5166		7.9738		555	23.5584		8.2179	
		.0222		.0053			.0212		.0049
508	22.5388		7.9791		556	23.5796		8.2228	
		.0222		.0052			.0212		.0050
509	22.5610		7.9843		557	23 6008		8.2278	
		.0221		.0052			.0212		.0049
510	22 5831		7.9895		558	23.6220		8.2327	
		.0222		.0052			.0211		.0049
511	22 6053		7.9947		559	23 6431		8 2376	
		.0221		.0053			.0212		.0049
512	22 6274		8 0000		560	23.6643		8.2425	
		.0221		.0052			.0211		.0049
513	22 6495		3 0052		561	23 6854		8 2474	
		.0220		.0052			.0211		.0049
514	22.6715		8 0104		562	23 7065		8.2523	
		.0221		.0051			.0211		.0049
515	22.6936		8 0155		563	23 7276		8 2572	
		.0220		.0052			.0210		.0049
516	22.7156		8 0207		564	23 7486		8 2621	
		.0220		.0052			.0211		.0049
517	22 7376		8.0259		565	23 7697		8.2670	
		.0220		.0052			.0210		.0049
518	22 7596		8.0311		566	23 7907		8.2719	
		.0219		.0051			.0210		.0048
519	22.7815		8.0362		567	23 8117		8.2767	
		.0220		.0052			.0210		.0949
520	22.8035		8.0414		568	23.8327		8.2816	
		.0219		.0052			.0210		.0048
521	22.8254		8.0466		569	23.8537		8.2864	

No	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
569	23.8537	.0209	8.2864	.0049	617	24.8394	.0202	8.5132	.0046
570	23.8746	.0210	8.2913	.0048	618	24.8596	.0201	8.5178	.0046
571	23.8956	.0209	8.2961	.0049	619	24.8797	.0200	8.5224	.0046
572	23.9165	.0209	8.3010	.0048	620	24.8997	.0201	8.5270	.0046
573	23.9374	.0208	8.3058	.0048	621	24.9198	.0201	8.5316	.0045
574	23.9582	.0209	8.3106	.0049	622	24.9399	.0200	8.5361	.0046
575	23.9791	.0209	8.3155	.0048	623	24.9599	.0200	8.5407	.0046
576	24.0000	.0208	8.3203	.0048	624	24.9799	.0201	8.5453	.0045
577	24.0208	.0208	8.3251	.0048	625	25.0000	.0199	8.5498	.0046
578	24.0416	.0208	8.3299	.0048	626	25.0199	.0200	8.5544	.0045
579	24.0624	.0207	8.3347	.0048	627	25.0399	.0200	8.5589	.0046
580	24.0831	.0208	8.3395	.0048	628	25.0599	.0199	8.5635	.0045
581	24.1039	.0207	8.3443	.0048	629	25.0798	.0200	8.5680	.0046
582	24.1246	.0207	8.3491	.0048	630	25.0998	.0199	8.5726	.0045
583	24.1453	.0207	8.3539	.0047	631	25.1197	.0199	8.5771	.0045
584	24.1660	.0207	8.3586	.0048	632	25.1396	.0198	8.5816	.0046
585	24.1867	.0207	8.3634	.0048	633	25.1594	.0199	8.5862	.0045
586	24.2074	.0206	8.3682	.0047	634	25.1793	.0199	8.5907	.0045
587	24.2280	.0207	8.3729	.0048	635	25.1992	.0198	8.5952	.0045
588	24.2487	.0206	8.3777	.0047	636	25.2190	.0198	8.5997	.0045
589	24.2693	.0206	8.3824	.0048	637	25.2388	.0198	8.6042	.0045
590	24.2899	.0205	8.3872	.0047	638	25.2586	.0198	8.6087	.0045
591	24.3104	.0206	8.3919	.0047	639	25.2784	.0198	8.6132	.0045
592	24.3310	.0205	8.3966	.0047	640	25.2982	.0197	8.6177	.0045
593	24.3515	.0206	8.4013	.0048	641	25.3179	.0198	8.6222	.0045
594	24.3721	.0205	8.4061	.0047	642	25.3377	.0197	8.6267	.0044
595	24.3926	.0205	8.4108	.0047	643	25.3574	.0197	8.6311	.0045
596	24.4131	.0204	8.4155	.0047	644	25.3771	.0197	8.6356	.0045
597	24.4335	.0205	8.4202	.0047	645	25.3968	.0197	8.6401	.0044
598	24.4540	.0204	8.4249	.0047	646	25.4165	.0196	8.6445	.0045
599	24.4744	.0204	8.4296	.0047	647	25.4361	.0197	8.6490	.0044
600	24.4948	.0205	8.4343	.0047	648	25.4558	.0196	8.6534	.0045
601	24.5153	.0203	8.4390	.0046	649	25.4754	.0196	8.6579	.0044
602	24.5356	.0204	8.4436	.0047	650	25.4950	.0197	8.6623	.0045
603	24.5560	.0204	8.4483	.0047	651	25.5147	.0195	8.6668	.0044
604	24.5764	.0203	8.4530	.0046	652	25.5342	.0196	8.6712	.0044
605	24.5967	.0203	8.4576	.0047	653	25.5538	.0196	8.6756	.0045
606	24.6170	.0203	8.4623	.0047	654	25.5734	.0195	8.6801	.0044
607	24.6373	.0203	8.4670	.0046	655	25.5929	.0195	8.6845	.0044
608	24.6576	.0203	8.4716	.0046	656	25.6124	.0196	8.6889	.0044
609	24.6779	.0202	8.4762	.0047	657	25.6320	.0195	8.6933	.0044
610	24.6981	.0203	8.4809	.0046	658	25.6515	.0194	8.6977	.0044
611	24.7184	.0202	8.4855	.0046	659	25.6709	.0195	8.7021	.0044
612	24.7386	.0202	8.4901	.0047	660	25.6904	.0195	8.7065	.0044
613	24.7588	.0202	8.4948	.0046	661	25.7099	.0194	8.7109	.0044
614	24.7790	.0201	8.4994	.0046	662	25.7293	.0194	8.7153	.0044
615	24.7991	.0202	8.5040	.0046	663	25.7487	.0194	8.7197	.0044
616	24.8193	.0201	8.5086	.0046	664	25.7681	.0194	8.7241	.0044
617	24.8394		8.5132		665	25.7875		8.7285	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
665	25 7875		8 7285		713	26.7020		8 9336	
666	25.8069	.0194	8 7328	.0043	714	26.7207	.0187	8 9378	.0042
667	25 8263	.0194	8 7372	.0044	715	26.7394	.0187	8 9420	.0042
668	25 8456	.0193	8 7416	.0044	716	26 7581	.0187	8.9461	.0041
669	25 8650	.0194	8 7459	.0043	717	26 7768	.0187	8.9503	.0042
670	25.8843	.0193	8.7503	.0044	718	26.7955	.0187	8.9545	.0042
671	25 9036	.0193	8.7546	.0043	719	26.8141	.0186	8 9586	.0041
672	25 9229	.0193	8.7590	.0044	720	26.8328	.0187	8 9628	.0042
673	25 9422	.0193	8.7633	.0044	721	26.8514	.0186	8.9669	.0041
674	25.9615	.0193	8.7677	.0044	722	26 8700	.0186	8.9711	.0042
675	25 9807	.0192	8.7720	.0043	723	26.8886	.0186	8 9752	.0041
676	26.0000	.0193	8.7763	.0043	724	26 9072	.0186	8.9793	.0041
677	26.0192	.0192	8.7807	.0044	725	26.9258	.0186	8.9835	.0042
678	26.0384	.0192	8 7850	.0043	726	26 9443	.0185	8 9876	.0041
679	26.0576	.0192	8 7893	.0043	727	26 9629	.0186	8 9917	.0041
680	26.0768	.0192	8 7936	.0043	728	26 9814	.0185	8 9958	.0041
681	26.0959	.0191	8 7979	.0043	729	27.0000	.0186	9 0000	.0042
682	26.1151	.0192	8 8022	.0043	730	27.0185	.0185	9 0041	.0041
683	26.1342	.0191	8.8065	.0043	731	27.0370	.0185	9.0082	.0041
684	26.1533	.0191	8 8108	.0043	732	27.0554	.0184	9 0123	.0041
685	26.1725	.0192	8.8151	.0043	733	27.0739	.0185	9.0164	.0041
686	26.1916	.0191	8.8194	.0043	734	27.0924	.0185	9.0205	.0041
687	26.2106	.0190	8.8237	.0043	735	27.1108	.0184	9.0246	.0041
688	26 2297	.0191	8 8280	.0042	736	27.1293	.0185	9.0287	.0041
689	26 2488	.0191	8 8322	.0043	737	27.1477	.0184	9.0328	.0041
690	26 2678	.0190	8.8365	.0043	738	27.1661	.0184	9 0368	.0040
691	26.2868	.0190	8.8408	.0042	739	27.1845	.0184	9.0409	.0041
692	26 3058	.0190	8.8450	.0043	740	27.2029	.0184	9 0450	.0041
693	26.3248	.0190	8 8493	.0042	741	27.2213	.0184	9.0491	.0041
694	26.3438	.0190	8 8535	.0043	742	27.2396	.0183	9 0531	.0040
695	26.3628	.0190	8 8578	.0042	743	27.2580	.0184	9.0572	.0041
696	26.3818	.0189	8 8620	.0043	744	27 2763	.0183	9.0613	.0041
697	26.4007	.0189	8 8663	.0042	745	27.2946	.0183	9.0653	.0040
698	26.4196	.0189	8 8705	.0043	746	27.3130	.0184	9.0694	.0041
699	26 4386	.0180	8 8748	.0042	747	27.3313	.0183	9.0734	.0040
700	26.4575	.0189	8 8790	.0042	748	27.3495	.0182	9 0775	.0041
701	26.4764	.0189	8 8832	.0042	749	27.3678	.0183	9.0815	.0040
702	26.4952	.0188	8 8874	.0043	750	27.3861	.0183	9.0856	.0041
703	26.5141	.0189	8 8917	.0042	751	27.4043	.0182	9.0896	.0040
704	26.5329	.0188	8.8959	.0042	752	27.4226	.0183	9.0936	.0040
705	26 5518	.0189	8.9001	.0042	753	27.4408	.0182	9.0977	.0041
706	26 5706	.0188	8.9043	.0042	754	27 4590	.0182	9.1017	.0040
707	26 5894	.0188	8.9085	.0042	755	27.4772	.0182	9.1057	.0040
708	26 6082	.0188	8.9127	.0042	756	27.4954	.0182	9.1097	.0040
709	26.6270	.0188	8.9169	.0042	757	27 5136	.0181	9.1137	.0040
710	26 6458	.0187	8.9211	.0042	758	27.5317	.0182	9.1177	.0041
711	26.6645	.0188	8.9253	.0041	759	27.5499	.0181	9.1218	.0040
712	26.6833	.0187	8.9294	.0042	760	27 5680	.0182	9.1258	.0040
713	26 7020		8.9336		761	27 5862		9.1298	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
761	27.5862	.0181	9.1298	.0040	809	28 4429	.0175	9.3178	.0038
762	27.6043	.0181	9 1338	.0039	810	28.4604	.0176	9.3216	.0039
763	27.6224	.0181	9.1377	.0040	811	28 4780	.0176	9.3255	.0038
764	27.6405	.0181	9 1417	.0040	812	28.4956	.0175	9.3293	.0038
765	27.6586	.0181	9.1457	.0040	813	28.5131	.0175	9.3331	.0039
766	27.6767	.0180	9 1497	.0040	814	28.5306	.0176	9.3370	.0038
767	27.6947	.0181	9 1537	.0040	815	28.5482	.0175	9.3408	.0038
768	27 7128	.0180	9 1577	.0039	816	28.5657	.0175	9.3446	.0038
769	27.7308	.0180	9 1616	.0040	817	28.5832	.0174	9 3484	.0038
770	27.7488	.0180	9.1656	.0040	818	28.6006	.0175	9.3522	.0038
771	27.7668	.0180	9.1696	.0039	819	28.6181	.0175	9.3560	.0039
772	27.7848	.0180	9.1735	.0040	820	28.6356	.0174	9.3599	.0038
773	27.8028	.0180	9.1775	.0040	821	28.6530	.0175	9.3637	.0038
774	27.8208	.0180	9.1815	.0039	822	28.6705	.0174	9.3675	.0038
775	27.8388	.0179	9 1854	.0040	823	28.6879	.0175	9.3713	.0037
776	27.8567	.0180	9 1894	.0039	824	28.7054	.0174	9.3750	.0038
777	27.8747	.0179	9.1933	.0039	825	28.7228	.0174	9.3788	.0038
778	27.8926	.0179	9.1972	.0040	826	28.7402	.0174	9.3826	.0038
779	27.9105	.0179	9 2012	.0039	827	28.7576	.0173	9.3864	.0038
780	27.9284	.0179	9 2051	.0039	828	28 7749	.0174	9.3902	.0038
781	27 9463	.0179	9.2090	.0040	829	28.7923	.0174	9.3940	.0037
782	27.9642	.0179	9.2130	.0039	830	28.8097	.0173	9.3977	.0038
783	27.9821	.0179	9 2169	.0039	831	28.8270	.0174	9.4015	.0038
784	28.0000	.0178	9 2208	.0039	832	28.8444	.0173	9 4053	.0038
785	28.0178	.0178	9 2247	.0040	833	28.8617	.0173	9 4091	.0037
786	28.0356	.0179	9 2287	.0039	834	28.8790	.0173	9.4128	.0038
787	28.0535	.0178	9.2326	.0039	835	28.8963	.0173	9.4166	.0037
788	28.0713	.0178	9.2365	.0039	836	28 9136	.0173	9.4203	.0038
789	28.0891	.0178	9 2404	.0039	837	28.9309	.0173	9.4241	.0037
790	28.1069	.0176	9.2443	.0039	838	28.9482	.0173	9.4278	.0038
791	28.1247	.0177	9 2482	.0039	839	28.9654	.0172	9 4316	.0037
792	28.1424	.0178	9.2521	.0039	840	28.9827	.0173	9.4353	.0038
793	28.1602	.0178	9 2560	.0039	841	29.0000	.0173	9.4391	.0037
794	28.1780	.0177	9 2599	.0038	842	29.0172	.0172	9.4428	.0038
795	28.1957	.0177	9.2637	.0039	843	29.0344	.0172	9.4466	.0037
796	28.2134	.0177	9 2676	.0039	844	29.0516	.0172	9.4503	.0037
797	28.2311	.0177	9.2715	.0039	845	29.0688	.0172	9.4540	.0037
798	28.2488	.0177	9.2754	.0039	846	29.0860	.0172	9.4577	.0038
799	28.2665	.0177	9 2793	.0038	847	29.1032	.0172	9.4615	.0037
800	28.2842	.0177	9 2831	.0039	848	29.1204	.0172	9.4652	.0037
801	28.3019	.0177	9 2870	.0039	849	29 1376	.0171	9.4689	.0037
802	28.3196	.0176	9.2909	.0038	850	29.1547	.0172	9.4726	.0038
803	28.3372	.0176	9.2947	.0039	851	29.1719	.0171	9.4761	.0040
804	28.3548	.0177	9 2986	.0038	852	29.1890	.0171	9.4801	.0037
805	28.3725	.0176	9.3024	.0039	853	29.2061	.0171	9.4838	.0037
806	28.3901	.0176	9 3063	.0038	854	29.2232	.0171	9.4875	.0037
807	28.4077	.0176	9 3101	.0039	855	29.2403	.0171	9.4912	.0037
808	28.4253	.0176	9 3140	.0038	856	29.2574	.0171	9.4949	.0037
809	28.4429		9 3178		857	29.2745		9.4986	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff.
857	29.2745	.0171	9.4986	.0037	905	30 0832	.0166	9.6727	.0036
858	29.2916	.0171	9.5023	.0036	906	30.0998	.0166	9.6763	.0035
859	29.3087	.0170	9 5059	.0037	907	30.1164	.0166	9.6798	.0036
860	29.3257	.0171	9.5096	.0037	908	30.1330	.0166	9.6834	.0035
861	29.3428	.0170	9 5133	.0037	909	30.1496	.0166	9.6869	.0036
862	29.3598	.0170	9.5170	.0037	910	30.1662	.0165	9.6905	.0035
863	29.3768	.0170	9.5207	.0037	911	30.1827	.0166	9.6940	.0036
864	29.3938	.0170	9.5244	.0036	912	30.1993	.0165	9.6976	.0035
865	29.4108	.0170	9.5280	.0037	913	30.2158	.0166	9 7011	.0035
866	29.4278	.0170	9.5317	.0037	914	30.2324	.0165	9.7046	.0036
867	29.4448	.0170	9 5354	.0036	915	30.2489	.0165	9.7082	.0035
868	29.4618	.0170	9.5390	.0037	916	30.2654	.0166	9.7117	.0036
869	29.4788	.0169	9.5427	.0037	917	30.2820	.0165	9.7153	.0035
870	29.4957	.0170	9.5464	.0036	918	30.2985	.0165	9.7188	.0035
871	29.5127	.0169	9.5500	.0037	919	30.3150	.0165	9.7223	.0035
872	29.5296	.0169	9.5537	.0036	920	30.3315	.0164	9.7258	.0036
873	29.5465	.0169	9.5573	.0037	921	30.3479	.0165	9.7294	.0035
874	29.5634	.0169	9.5610	.0036	922	30 3644	.0165	9.7329	.0035
875	29.5803	.0169	9 5646	.0036	923	30.3809	.0164	9.7364	.0035
876	29.5972	.0169	9.5682	.0037	924	30.3973	.0165	9.7399	.0035
877	29.6141	.0169	9.5719	.0036	925	30.4138	.0164	9.7434	.0035
878	29.6310	.0169	9.5755	.0037	926	30.4302	.0164	9.7469	.0035
879	29.6479	.0168	9 5792	.0036	927	30.4466	.0164	9.7504	.0035
880	29.6647	.0169	9 5828	.0036	928	30.4630	.0165	9.7539	.0036
881	29.6816	.0168	9.5864	.0036	929	30.4795	.0164	9.7575	.0035
882	29.6984	.0169	9.5900	.0037	930	30.4959	.0163	9.7610	.0044
883	29.7153	.0168	9.5937	.0036	931	30.5122	.0164	9 7644	.0035
884	29.7321	.0168	9.5973	.0036	932	30.5286	.0164	9.7679	.0035
885	29.7489	.0168	9 6009	.0036	933	30.5450	.0164	9.7714	.0035
886	29.7657	.0168	9 6045	.0036	934	30.5614	.0163	9.7749	.0035
887	29.7825	.0168	9.6081	.0036	935	30.5777	.0164	9 7784	.0035
888	29.7993	.0168	9.6117	.0036	936	30.5941	.0163	9.7829	.0035
889	29.8161	.0167	9.6153	.0037	937	30.6104	.0163	9.7854	.0035
890	29.8328	.0168	9.6190	.0036	938	30.6267	.0164	9.7889	.0034
891	29.8496	.0167	9.6226	.0036	939	30.6431	.0163	9 7923	.0035
892	29.8663	.0168	9 6262	.0035	940	30.6594	.0163	9.7958	.0035
893	29.8831	.0167	9.6297	.0036	941	30.6757	.0163	9 7993	.0035
894	29.8998	.0167	9.6333	.0036	942	30.6920	.0163	9.8028	.0034
895	29.9165	.0167	9.6369	.0036	943	30 7083	.0162	9.8062	.0035
896	29.9332	.0167	9.6405	.0036	944	30.7245	.0163	9.8097	.0034
897	29 9499	.0167	9.6441	.0036	945	30.7408	.0163	9.8131	.0035
898	29.9666	.0167	9.6477	.0036	946	30 7571	.0162	9 8166	.0035
899	29.9833	.0167	9.6513	.0035	947	30.7733	.0163	9.8201	.6034
900	30.0000	.0166	9.6548	.0036	948	30 7896	.0162	9.8235	.0035
901	30.0166	.0167	9 6584	.0036	949	30 8058	.0162	9.8270	.0034
902	30.0333	.0166	9 6620	.0036	950	30.8220	.0162	9 8304	.0035
903	30.0499	.0166	9.6656	.0035	951	30.8382	.0162	9.8339	.0034
904	30.0665	.0167	9.6691	.0036	952	30.8544	.0162	9.8373	.0035
905	30.0832		9.6727		953	30.8706		9.8408	

No.	Sqr. Rts.	Diff.	C. Rts.	Diff.	No.	Sqr. Rts.	Diff.	C. Rts.	Diff
953	30.8706	.0162	9.8408	.0034	977	31.2569	.0160	9.9227	.0034
954	30.8868	.0162	9.8442	.0034	978	31.2729	.0160	9.9261	.0034
955	30.9030	.0162	9.8476	.0035	979	31.2889	.0160	9.9295	.0033
956	30.9192	.0162	9.8511	.0034	980	31.3049	.0160	9.9328	.0034
957	30.9354	.0161	9.8545	.0034	981	31.3209	.0159	9.9362	.0034
958	30.9515	.0162	9.8579	.0035	982	31.3368	.0160	9.9396	.0034
959	30.9677	.0161	9.8614	.0034	983	31.3528	.0159	9.9430	.0033
960	30.9838	.0162	9.8648	.0034	984	31.3687	.0160	9.9463	.0034
961	31.0000	.0161	9.8682	.0034	985	31.3847	.0159	9.9497	.0034
962	31.0161	.0161	9.8716	.0035	986	31.4006	.0159	9.9531	.0033
963	31.0322	.0161	9.8751	.0034	987	31.4165	.0159	9.9564	.0034
964	31.0483	.0161	9.8785	.0034	988	31.4324	.0159	9.9598	.0033
965	31.0644	.0161	9.8819	.0034	989	31.4483	.0159	9.9631	.0034
966	31.0805	.0161	9.8853	.0034	990	31.4642	.0159	9.9665	.0034
967	31.0966	.0160	9.8887	.0034	991	31.4801	.0159	9.9699	.0033
968	31.1126	.0161	9.8921	.0034	992	31.4960	.0159	9.9732	.0034
969	31.1287	.0161	9.8955	.0034	993	31.5119	.0158	9.9766	.0033
970	31.1448	.0160	9.8989	.0034	994	31.5277	.0159	9.9799	.0034
971	31.1608	.0161	9.9023	.0034	995	31.5436	.0158	9.9833	.0033
972	31.1769	.0160	9.9057	.0034	996	31.5594	.0159	9.9866	.0033
973	31.1929	.0160	9.9091	.0034	997	31.5753	.0158	9.9899	.0034
974	31.2089	.0160	9.9125	.0034	998	31.5911	.0158	9.9933	.0033
975	31.2249	.0160	9.9159	.0034	999	31.6069	.0158	9.9966	.0034
976	31.2409	.0160	9.9193	.0034	1000	31.6227		10.0000	
977	31.2569		9.9227						

TABLE

CONTAINING

THE SURFACE AND SOLIDITY OF SPHERES,

The Edge or Dimensions of Equal Cubes,

THE LENGTHS OF EQUAL CYLINDERS,

AND THE

WEIGHT OF EQUAL QUANTITIES OF WATER IN AVOIRDUPOIS LBS.

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
1 in.	3.1416	.5236	.8060	.6666	.0190
1/16	3.5465	.6280	.8563	.7082	.0227
1/8	3.9760	.7455	.9067	.7500	.0270
3/16	4.4301	.8767	.9571	.7917	.0317
1/4	4 9087	1.0226	1.0075	.8333	.0370
5/16	5.4117	1.1838	1.0578	.8750	.0428
3/8	5 9395	1.3611	1.1082	.9166	.0500
7/16	6.4918	1.5553	1.1586	.9583	.0563
1/2	7.0686	1.7671	1.2090	1.0000	.0640
9/16	7.6699	2 0000	1.2593	1.0416	.0723
5/8	8.2957	2.2467	1.3097	1.0833	.0813
11/16	8.9461	2 5161	1.3601	1.1349	.0910
3/4	9.6211	2 8061	1.4105	1.1666	.1015
13/16	10 3206	3.1176	1.4608	1.2083	.1128
7/8	11.0446	3 4514	1.5112	1.2500	.1250
15/16	11.7932	3 8081	1.5616	1.2916	.1377
2 in.	12 5664	4 1888	1.6020	1.3333	.1516
1/16	13.3640	4 5938	1.6633	1.3750	.1662
1/8	14.1862	5.0243	1.7127	1.4166	.1818
3/16	15.0330	5.4807	1.7631	1.4582	.1982
1/4	15.9043	5.9640	1.8135	1.5000	.2160
5/16	16.8000	6.4749	1.8638	1.5516	.2342
3/8	17.7205	7.0143	1.9142	1.5832	.2540
7/16	18.6655	7.5828	1.9646	1.6250	.2743
1/2	19.6350	8.1812	2.0150	1.6666	.2960
9/16	20.6290	8.8103	2.0653	1.7082	.3187
5/8	21.6475	9.4708	2.1157	1.7500	.3426
11/16	22.6907	10.1634	2.1661	1.7915	.3676
3/4	23 7583	10.8892	2.2165	1.8332	.3939
13/16	24.8505	11.6485	2.2668	1 8750	.4213
7/8	25 9672	12 4426	2 3172	1.9165	.4501
15/16	27.1084	13 2718	2.3676	1.9582	.4800
3 in.	28.2744	14.1372	2.4180	2.0000	.5114
1/16	29.4647	15.0392	2.4683	2.0415	.5440
1/8	30.6796	15.9790	2.5187	2.0832	.5780
3/16	31.9191	16.9570	2.5691	2.1250	.6133
1/4	33.1831	17 9742	2 6195	2.1665	.6401
5/16	35.3715	19.0311	2.6698	2.2082	.6884
3/8	35.7847	20 1289	2 7202	2 2500	.7281
7/16	37.1224	21.2680	2.7706	2.2915	.7693
1/2	38.4846	22.4493	2.8210	2 3332	.8120
9/16	39.8713	23.6735	2 8713	2.3750	.8561
5/8	41.2825	24 9415	2.9217	2.4166	.9021
11/16	42.7183	26.2539	2.9712	2.4582	.9496
3/4	44.1787	27.6117	3.0225	2.5000	.9987
13/16	45.6636	29.0102	3.0728	2.5415	1.0493
7/8	47.1730	30.4659	3.1232	2.5832	1.1020
15/16	48.7070	31.9640	3.1730	2.6250	1.1561

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
4 in.	50.2656	33.5104	3.2240	2.6665	1.1974
1/16	51.8486	35.1058	3.2743	2.7082	1.2698
1/8	53.4562	36.7511	3.3247	2.7500	1.3293
3/16	55.0884	38.4471	3.3751	2.7915	1.3906
1/4	56.7451	40.1944	3.4255	2.8332	1.4538
5/16	58.4262	42.0461	3.4758	2.8750	1.5208
3/8	60.1321	43.8463	3.5262	2.9165	1.5860
7/16	61.8625	45.7524	3.5766	2.9582	1.6550
1/2	63.6174	47.7127	3.6270	3.0000	1.7258
9/16	65.3968	49.7290	3.6773	3.0415	1.7987
5/8	67.2007	51.8006	3.7277	3.0832	1.8736
11/16	69.0352	53.9290	3.7781	3.1250	1.9506
3/4	70.8823	56.1151	3.8285	3.1665	2.0297
13/16	72.7599	58.3595	3.8788	3.2080	2.1109
7/8	74.6620	60.6629	3.9292	3.2500	2.1942
15/16	76.5887	62.9261	3.9796	3.2913	2.2760
5 in.	78.5400	65.4500	4.0300	3.3332	2.3673
1/16	80.5157	67.9351	4.0803	3.3750	2.4572
1/8	82.5160	70.4824	4.1307	3.4155	2.5453
3/16	84.5409	73.0926	4.1811	3.4582	2.6438
1/4	86.5903	75.7664	4.2315	3.5000	2.7605
5/16	88.6641	78.5077	4.2818	3.5414	2.8396
3/8	90.7627	81.3083	4.3322	3.5832	2.9407
7/16	92.8858	84.1777	4.3820	3.6250	3.0447
1/2	95.0334	87.1139	4.4330	3.6665	3.1509
9/16	97.2053	90.1175	4.4833	3.7080	3.2595
5/8	99.4021	93.1875	4.5337	3.7500	3.3706
11/16	101.6233	96.3304	4.5841	3.7913	3.4843
3/4	103.8691	99.5412	4.6345	3.8330	3.6004
13/16	106.1394	102.8225	4.6848	3.8750	3.7191
7/8	108.4342	106.1754	4.7352	3.9163	3.8404
15/16	110.7536	109.5973	4.7856	3.9580	3.9641
6 in.	113.0976	113.0976	4.8360	4.0000	4.0907
1/16	115.4660	116.6688	4.8863	4.0417	4.2200
1/8	117.8590	120.3139	4.9367	4.0833	4.3517
3/16	120.2771	124.0374	4.9871	4.1250	4.4874
1/4	122.7187	127.8320	5.0375	4.1666	4.6236
5/16	125.1852	131.7053	5.0878	4.2083	4.7638
3/8	127.6765	135.6563	5.1382	4.2500	4.9067
7/16	130.1923	139.6854	5.1886	4.2917	5.0524
1/2	132.7326	143.7936	5.2390	4.3332	5.2010
9/16	135.2974	147.9815	5.2893	4.3750	5.3525
5/8	137.8867	152.2499	5.3577	4.4165	5.5069
11/16	140.5006	156.5997	5.3901	4.4583	5.6786
3/4	143.1391	161.0315	5.4405	4.5000	5.8245
13/16	145.8021	167.5461	5.4908	4.5416	6.0601
7/8	148.4896	170.1682	5.5412	4.5832	6.1550
15/16	151.2017	174.8270	5.5916	4.6250	6.3235

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
7 in.	153.9384	179.5948	5.6420	4.6665	6.4960
1/16	156.6995	184.4484	5.6928	4.7062	6.6725
1/8	159.4852	189.3882	5.7427	4.7500	6.8502
3/16	162.2955	194.1165	5.7931	4.7915	7.0212
1/4	165.1303	199.5325	5.8435	4.8332	7.2171
5/16	167.9895	204.7371	5.8938	4.8750	7.4053
3/8	170.8735	210.0331	5.9442	4.9166	7.5970
7/16	173.7520	215.4172	5.9945	4.9582	7.7916
1/2	176.7150	220.8937	6.0450	5.0000	7.9697
9/16	179.6725	226.7240	6.0953	5.0415	8.2006
5/8	182.6545	232.1235	6.1457	5.0832	8.3960
11/16	185.6611	237.8883	6.1961	5.1250	8.6044
3/4	188.6923	243.7276	6.2465	5.1665	8.8157
13/16	191.7480	249.4720	6.2968	5.2082	9.0234
7/8	194.8282	255.7121	6.3472	5.2500	9.2491
15/16	197.9330	261.9673	6.3976	5.2913	9.4753
8 in.	201.0624	268.0832	6.4480	5.3330	9.6965
1/16	204.2162	274.4156	6.4983	5.3750	9.9260
1/8	207.3946	280.8469	6.5487	5 4164	10.1583
3/16	210.5976	287.3780	6.5991	5.4581	10.3944
1/4	213.8251	294.0095	6.6495	5.5000	10.6343
5/16	217.0770	300.7422	6.6998	5.5414	10.8778
3/8	220.3537	307.5771	6.7502	5.5831	11.1250
7/16	223.6549	314.5147	6.8006	5 6250	11.3760
1/2	226.9806	321.5553	6.8510	5.6664	11.6306
9/16	230.3308	328.7012	6.9013	5.7080	11.8891
5/8	233.7055	335.9517	6.9517	5.7500	12.1514
11/16	237.1048	343.3079	7.0021	5.7915	12.4170
3/4	240.5287	350.7710	7.0525	5.8330	12.6874
13/16	243.9771	358.3412	7.1028	5.8750	12.9612
7/8	247.4500	366.0199	7.1532	5 9163	13.2390
15/16	250.9475	373.8073	7.2036	5.9580	13 5206
9 in.	254.4696	381.7017	7.2540	6.0000	13.8062
1/16	258.0261	389.7118	7.3043	6.0417	14.0959
1/8	261.5872	397.8306	7.3547	6.0833	14.3895
3/16	265.1829	406.0613	7.4051	6.1250	14 6872
1/4	268.8031	414.4048	7.4555	6.1667	14 9890
5/16	272.4477	421.2907	7.5058	6.2083	15 2381
3/8	276.1171	431.4361	7.5562	6.2500	15.6030
7/16	279.8110	440.1294	7.6066	6.2916	15.9195
1/2	283.5294	448.9215	7.6570	6.3333	16.2375
9/16	287.2723	457.8500	7.7073	6.3750	16.5604
5/8	291.0397	466.8763	7.7557	6.4166	16.6869
11/16	294.8310	476.0304	7.8081	6.4582	17.2186
3/4	298 4483	485.3035	7.8585	6.5000	17.5534
13/16	302.4894	494.6952	7.9088	6.5415	17.8931
7/8	306.3550	504.2094	7.9592	6.5832	18 2373
15/16	310.9452	513.8436	8.0096	6.6250	18.5857

Dia.	Surface.	Solidity.	Cube.	Cylinder.	Water in lbs.
10 in.	314.1600	523.6000	8.0600	6.6666	18.6786
1/16	318.0992	533.4789	8.1103	6.7083	19.2960
1/8	322.0650	543.4814	8.1607	6.7500	19.6577
3/16	326.0514	553.6081	8.2111	6.7916	20.0240
1/4	330.0643	563.8603	8.2615	6.8333	20.3948
5/16	334.1016	574.2371	8.3118	6.8750	20.6682
3/8	338.1637	584.7415	8.3622	6.9166	21.1501
7/16	342.2503	595.3677	8.4126	6.9582	21.5344
1/2	346.3614	606.1318	8.4630	7.0000	21.9238
9/16	350.4970	617.0207	8.5133	7.0416	22.3176
5/8	354.6571	628.0387	8.5637	7.0833	22.7162
11/16	358.8418	639.1871	8.6141	7.1250	23.1194
3/4	363.0511	650.4666	8.6645	7.1666	23.5274
13/16	367.2849	661.8580	8.7148	7.2082	23.9394
7/8	371.5432	673.4222	8.7652	7.2500	24.3577
15/16	375.8261	685.0997	8.8156	7.2915	24.7801
11 in.	380.1336	696.9116	8.8660	7.3330	25.2073
1/16	384.4655	708.9106	8.9163	7.3750	25.6414
1/8	388.8220	720.9409	8.9667	7.4165	26.0764
3/16	393.2031	733.1599	9.0171	7.4582	26.5184
1/4	397.6087	745.5004	9.0675	7.5000	26.5657
5/16	402.0387	758.0104	9.1178	7.5414	27.4162
3/8	406.4935	770.6440	9.1682	7.5832	27.8742
7/16	410.7728	783.5787	9.2186	7.6250	28.3420
1/2	415.4766	796.3301	9.2690	7.6664	28.8033
9/16	420.0049	809.3844	9.3193	7.7080	29.2754
5/8	424.5576	822.5807	9.3697	7.7500	29.7527
11/16	429.1351	835.9695	9.4201	7.7913	30.2370
3/4	433.7371	849.4035	9.4705	7.8330	30.7229
13/16	438.3636	863.0283	9.5208	7.8750	31.2157
7/8	443.0146	876.7999	9.5772	7.9163	31.3883
15/16	447.6902	890.7070	9.6216	7.9580	32.2169
12 in.	452.3904	904.7808	9.6720	8.0000	32.7259
1/4	471.4363	962.5158	9.8735	8.1666	34.8142
1/2	490.8750	1022.656	10.0750	8.3332	36.9886
3/4	506.7064	1085.251	10.2765	8.5000	39.2535
13 in.	530.9304	1150.337	10.4780	8.6666	41.6077
1/4	551.5471	1218.009	10.6790	8.8332	44.0551
1/2	572.5566	1288.252	10.8810	9.0000	46.5961
3/4	593.9587	1361.346	11.0825	9.1665	49.2399
14 in.	615.7536	1436.758	11.2840	9.3332	51.9675
1/4	637.9411	1515.106	11.4855	9.5000	54.8014
1/2	660.5214	1596.260	11.6870	9.6665	57.7367
3/4	683.4943	1680.265	11.8885	9.8332	60.7751
15 in.	706 8600	1767.150	12.0900	10.0000	64.0178
1/4	730.6183	1856.988	12.2915	10.1666	67.1672
1/2	754.7694	1949.821	12.4930	10 3332	70.5250
3/4	779.3131	2045 697	12.6940	10.5000	73.9929
16 in.	804.2496	2144.665	12 8960	10.6666	77.5725

TABLE

Combining the Specific Gravities and other Properties of Bodies. Water the standard of comparison, or 1000.

Names.	Specific gravity.	METALS. Melting points in degrees of Fahrenheit.	Contraction in parts of an in. per lineal ft. from the fluid to the average temperature in solid state.	Ultimate cohesive strength of an inch sq. prism in tons.	Scale of wire-drawing ductility.	Scale of laminable ductility.	Ratio of hardness.	Scale as conductors of electricity.	Ratio of power in the conduction of heat.
Platinum	19500	3280	..	..	3	5	..	..	3.8
Pure Gold	19258	2016	..	..	1	1	1.8	3	10.0
Mercury	13500	..	..	..	..	..	..	..	..
Lead	11352	612	.319	.81	8	7	1.0	6	1.8
Pure Silver	10474	1873	..	..	2	2	2.4	2	9.7
Bismuth	9823	476	.156	1.45	..	..	2.0	..	..
Copper, cast	8788	1996	.193	8.51	..	..	..	..	..
„ wrought	8910	..	..	15.08	5	3	2.8	1	8.9
Brass, cast	7824	1900	.210	8.01	..	..	to any degree	..	..
„ sheet	8396	..	..	12.23	6	6	..	..	8.6
Iron, cast	7264	2786	.125	7.87	..	..	to any degree	..	..
„ bar	7700	..	.137	25.00	4	8	4.7	4	3.7
Steel, soft	7833	..	.133	58.91	..	..	..	..	..
„ hard	7816	..	..	..	..	..	to any degree	..	..
Tin, cast	7291	442	.278	2.11	8	4	1.2	5	3.0
Zinc, cast	7190	773	.329	5.06	7	8	1.6	7	3.6

Names.	STONES, EARTHS, &c. Specific gravity.	Weight of a cubic foot in lbs.	Cubic feet in a ton.	Tons required to crush 1½-inch cubes.
Marble, average	2720	170.00	13	9.25
Granite, ditto	2651	165.68	13½	6.2
Purbeck stone	2601	162.56	13¾	9.0
Portland ditto	2570	160.62	14	4.5
Bristol ditto	2554	159.62	14	..
Millstone	2484	155.25	14¼	..
Paving stone	2415	150.93	14½	5.7
Craigleith ditto	2362	147.62	15	5.0
Grindstone	2143	133.93	16¾	6.6
Chalk, Brit	2781	173.81	12¾	0.5
Brick	2000	125.00	17	0.8
Coal, Scotch	1300	81.15	27½	..
„ Newcastle	1270	79.37	27¾	..
„ Staffordsh.	1240	77.50	29	..
„ Cannel	1238	77.37	29	..

TABLE

CONTAINING

THE WEIGHT OF COLUMNS OF WATER,

EACH ONE FOOT IN LENGTH,

AND OF VARIOUS DIAMETERS,

IN LBS. AVOIRDUPOIS.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
3 *in.*	3.0672	9 *in.*	27.6120	15 *in.*	76.7004
⅛	3.3288	⅛	28.3848	⅛	77.9844
¼	3.6000	¼	29.1672	¼	79.2792
⅜	3.8820	⅜	29.9604	⅜	80.5836
½	4.1748	½	30.7657	½	81.9000
⅝	4.4784	⅝	31.6524	⅝	83.2260
¾	4.7928	¾	32.4060	¾	84 5628
⅞	5.1180	⅞	33.2424	⅞	85.9104
4 *in.*	5.4540	10 *in.*	34.0884	16 *in.*	87.2688
⅛	5.7996	⅛	34.9464	⅛	88.6368
¼	6.1572	¼	35.8152	¼	90.0168
⅜	6.5244	⅜	36.6936	⅜	91.4176
½	6.9024	½	37.5828	½	92 8080
⅝	7.2912	⅝	38.4828	⅝	94.2192
¾	7.6908	¾	39.3936	¾	95.6412
⅞	8.1012	⅞	40.3152	⅞	97.0740
5 *in.*	8.5212	11 *in.*	41.2476	17 *in.*	98.5176
⅛	8.9532	⅛	42.1908	⅛	99.9720
¼	9.3948	¼	43.1436	¼	101.4372
⅜	9.8484	⅜	44.1084	⅜	102.9120
½	10.3126	½	45.0828	½	104.3988
⅝	10.7856	⅝	46.0680	⅝	105.8952
¾	11.2704	¾	47.0640	¾	107.4024
⅞	11.7660	⅞	48 0708	⅞	108.9204
6 *in*	12.2712	12 *in.*	49.0884	18 *in.*	110.4492
⅛	12.7884	⅛	50.1168	⅛	111.9888
¼	13.3152	¼	51.1548	¼	113.5392
⅜	13.8540	⅜	52.2048	⅜	115.0992
½	14.4024	½	53.2644	½	116.6712
⅝	14.9616	⅝	54.3348	⅝	118.2528
¾	15.5316	¾	55.4760	¾	119.8452
⅞	16.1124	⅞	56.4804	⅞	121.4484
7 *in.*	16.7028	13 *in*	57.6108	19 *in.*	123.0624
⅛	17.3052	⅛	58.7244	⅛	124.6872
¼	17.9172	¼	59.8476	¼	126.3228
⅜	18.5412	⅜	60.9828	⅜	127.9680
½	19.1748	½	62.1276	½	129.6252
⅝	19.8192	⅝	63.2832	⅝	131.5320
¾	20.4744	¾	64.4496	¾	132.9696
⅞	21.1404	⅞	65.6268	⅞	134.6580
8 *in.*	21.8172	14 *in.*	66.8148	20 *in.*	136.3562
⅛	22.5036	⅛	68.0136	⅛	138.0672
¼	23.2020	¼	69.2220	¼	139.7880
⅜	23 9100	⅜	70.4424	⅜	141.5184
½	24.5288	½	71.6724	½	143.2608
⅝	25.3524	⅝	72.9120	⅝	145.0128
¾	26.0988	¾	74.1648	¾	146.7756
⅞	26.8500	⅞	75.4272	⅞	148.5492

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
21 *in.*	150.2376	27 *in.*	248 5116	33 *in.*	371.2344
⅛	152.1288	⅛	250.8180	⅛	374.0520
¼	153.9348	¼	253.1352	¼	376 8004
⅜	155.7396	⅜	255.4632	⅜	379.4592
½	157.5780	½	257.8008	½	382.5684
⅝	159.4152	⅝	260.1504	⅝	385 4292
¾	161.2644	¾	262 5096	¾	388.2996
⅞	163.1220	⅞	264.8796	⅞	391.1820
22 *in.*	164.9928	28 *in.*	267.2616	34 *in*	394 0740
⅛	166.8732	⅛	269.6532	⅛	396.9768
¼	168.7632	¼	272 0544	¼	399 8928
⅜	170.6652	⅜	275 6672	⅜	402 8088
½	172.5780	½	276 8916	½	405 7500
⅝	174.5004	⅝	279.3252	⅝	408 6948
¾	176.4336	¾	281.7708	¾	411.4116
⅞	178 3776	⅞	284 2260	⅞	414 6180
23 *in.*	180.3324	29 *in.*	286.6920	35 *in.*	417.5952
⅛	182 2980	⅛	289 1688	⅛	420.5844
¼	184.2744	¼	291 6564	¼	423 5832
⅜	186.2616	⅜	294.1548	⅜	426.5928
½	188.2584	½	296.5548	½	429.6120
⅝	190.2672	⅝	299.1828	⅝	432.6432
¾	192.2856	¾	301 7124	¾	435.6840
⅞	194.3184	⅞	304 2540	⅞	438 7368
24 *in.*	196.3548	30 *in.*	306 8052	36 *in.*	441 7992
⅛	198.4056	⅛	309 3672	¼	447 9573
¼	200.4672	¼	311,9400	½	454.1678
⅜	203 5384	⅜	314.5224	¾	460 4105
½	204.6216	½	317.1168	37 *in.*	466 6960
⅝	206.7144	⅝	319 7220	¼	473 0240
¾	208 8192	¾	322.3368	½	479 3946
⅞	210.9336	⅞	324 9624	¾	485.8078
25 *in.*	213.0588	31 *in.*	327 6000	38 *in.*	492.2637
⅛	215.1948	⅛	330.2472	¼	498.7621
¼	217.3416	¼	332 9052	½	505.3032
⅜	219.4980	⅜	335.5728	¾	511 9979
½	221.6664	½	338 2524	39 *in.*	518 4132
⅝	223.8444	⅝	340,9428	¼	525 1821
¾	226.0344	¾	343.6428	½	531.8936
⅞	228.2340	⅞	346 3536	¾	538 6478
26 *in.*	230.4444	32 *in.*	349 0764	40 *in.*	545 4445
⅛	232.6644	⅛	351.8088	¼	552.2839
¼	234.8576	¼	354 5520	½	559.1659
⅜	237.1404	⅜	357.3048	¾	566.0904
½	239.3928	½	360.0696	41 *in.*	573.0577
⅝	241.6572	⅝	362.8452	½	587.1199
¾	243.9312	¾	365 6304	42 *in.*	601.3526
⅞	246.2160	⅞	368 4276	50 *in.*	799 2428

The preceding tables are rendered of great utility by means of the following:—

The weight of Water		being	1.
———	Copper	=	8.8
———	Brass	=	8.4
———	Iron, cast	=	7.2
———	Lead	=	11.3
———	Zinc	=	7.2
———	Gun metal	=	8.7
———	Sand	=	1.5
———	Coal	=	1.25
———	Brick	=	2.0
———	Stone	=	2.5
———	Timber, average	=	0.85

EXAMPLE.—Suppose it be required to ascertain the weight of a cast iron pipe $26\frac{1}{4}$ inches outside and $23\frac{3}{4}$ inside, the length being $6\frac{1}{2}$ feet.

Opposite $26\frac{1}{4}$ in the table is

$234.8576 \times 7.2 \times 6.5 = 10991.135$

And opposite $23\frac{3}{4}$ in the table is

$192.2856 \times 7.2 \times 6.5 = 8998.966$ subtract

1992.169 lbs. Avs.

And in a similar manner the weight of a column or pipe of another material can easily be obtained.

SMITH, ROGERSON, AND CO., PRINTERS, LIVERPOOL.